AERONAUTICAL ENGINEERING REVIEW

MAY 1951

ELECTRONICS IN AVIATION

A CASE HISTORY OF

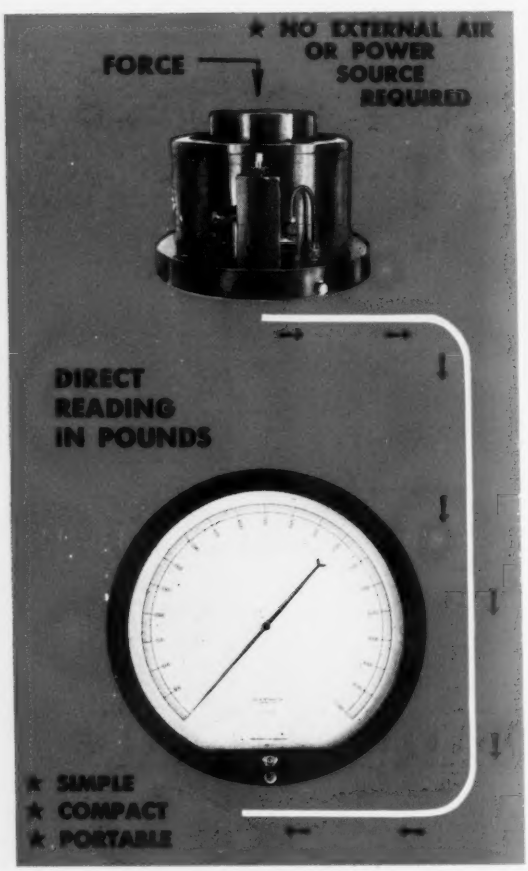
WHY

- HIGH NATURAL FREQUENCY
- INHERENT FAST RESPONSE
- CONTROLLED READABILITY

ARE IMPORTANT ADVANTAGES OF THE

EMERY FORCE MEASURING SYSTEM

THE PROBLEM: A leading manufacturer wished to accurately read loads on a dynamometer for testing engines.
The torque measuring system they were using failed to provide accurate or usable readings; external vibration was present and the system went into resonant vibration at points where accurate readings were most desired. Even minor variations in the load produced erratic readings.



HOW EMERY SOLVED THIS PROBLEM

HIGH NATURAL FREQUENCY: A typical Emery cell has a deflection of less than .005" for full capacity and a high natural resonant frequency of 40,000 cycles per minute. This frequency was far above the external disturbing frequencies encountered in the above problem (and actually far above any such disturbances found in usual applications). A precise and steady dial reading is now obtained over the full range of testing speeds.

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CONTROLLED READABILITY: Response of the indicator can be that of the inherent fast speed above, or it can be controlled by one simple Emery valve to follow and read load fluctuations, or to provide a steady reading of the mean value of a vibrating load. This control was another major factor in solving the problem described above, and in many other installations.

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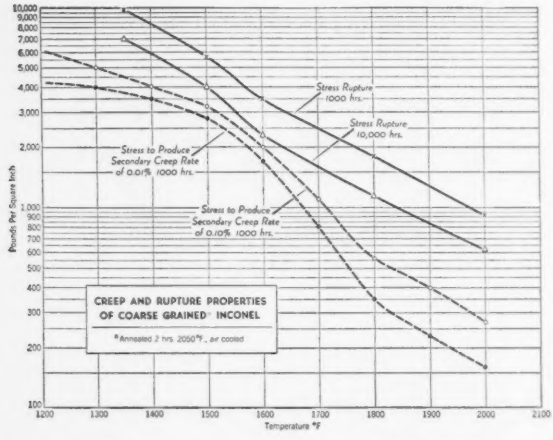
Pounds Per Square Inch
Temperature °F
Stress Rupture 1000 hrs.
Stress Rupture 10,000 hrs.
Stress to Produce Secondary Creep Rate of 0.01% 1000 hrs.
Stress to Produce Secondary Creep Rate of 0.10% 1000 hrs.
CREEP AND RUPTURE PROPERTIES OF COARSE GRAINED* INCONEL
*Annealed 2 hrs. 2050°F., air cooled

Creep- and stress-rupture data for INCONEL up to 2000°F are outlined in this chart.

Room temperature mechanical property ranges of INCONEL mill forms are shown in the following table:

Corrosion Resistance. The chromium content of INCONEL raises its oxidation resistance considerably above that of pure nickel, while at the same time its high nickel content provides high corrosion resistance under reducing conditions. It is highly resistant to fresh and salt water, exhaust gases, and most organic acids and compounds.

Fabrication. INCONEL is workable, both hot and cold. It is machinable, though high-speed steel tools should be used. It can be joined by the usual welding, brazing, and soldering processes common to industry.

Applications. INCONEL is used for manifolds, collector rings, heaters, lock wires, gaskets, jet blankets and combustion liners, thermo-couple coverings, domes and transition units in jet-propelled aircraft.

Forms Supplied. INCONEL is produced in the usual mill forms—billets, rods, rounds, flats, hexagons, sheet and strip, bars, tubing, wire, and a new T section. It is also produced in sand, centrifugal and precision castings.

FOR FURTHER INFORMATION

ENGINEERING PROPERTIES OF INCONEL is a Technical Bulletin on Inconel that gives a full, factual story. It is punched for ring book insertion, and will be sent, free, on request for *Technical Bulletin T-7*. And for technical help on specific high-temperature metal problems, write fully to INCO's Technical Service Section.

MECHANICAL PROPERTY RANGES OF INCONEL

Form and Condition	Tensile Properties				Hardness		Impact Strength Charpy U-Notch ft-lb
	Tensile Strength 1000 psi	Yield Strength (0.2% offset) 1000 psi	Elongation in 2 in. %	Reduction of area %	Brinell 3000 Kg	Rockwell	
Rod and Bar							
Cold Drawn Annealed	80-100	25-50	55-35	70-60	120-170	65-85B	230
As-Drawn	105-150	80-125	30-10	60-30	180-290	90B-30C	151
Hot-Rolled	80-120	25-90	55-30	70-50	120-210	65-95	191-230
Wire							
Cold Drawn Annealed	80-105	25-50	50-25	—	—	—	—
Regular temper	130-175	115-165	12-3	—	—	—	—
Spring	165-185	150-175	10-2	—	—	—	—
Sheet							
Cold Rolled Annealed	80-100	30-45	55-35	—	—	88B max.	—
Deep Drawing & Spinning quality	80-100	30-45	55-40	—	—	65-80B	—
Strip							
Annealed	80-100	30-45	55-35	—	—	84B max.	—
Spring temper	145-170	120-160	10-2	—	—	30C min.	—

Impact Strength. Charpy tests reveal impact strength ranging from 187 ft.-lb. at sub-zero temperatures to 154 ft.-lb. at 1400°F.

Spring Properties. INCONEL is used regularly for springs at temperatures of 500 to 600°F, because of its resistance to relaxation or load loss in this range.

Low-Temperature Properties. INCONEL gives excellent performance in sub-zero temperatures. Strength factors *increase* considerably in this range, *without* appreciable loss of ductility or toughness.

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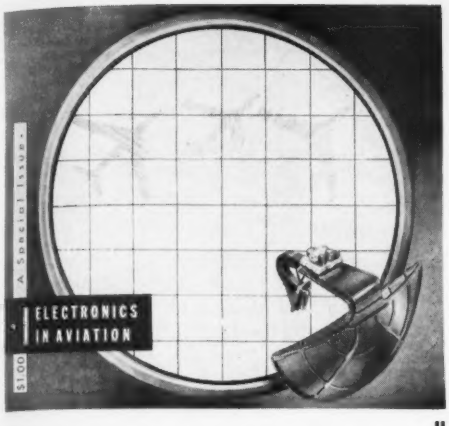

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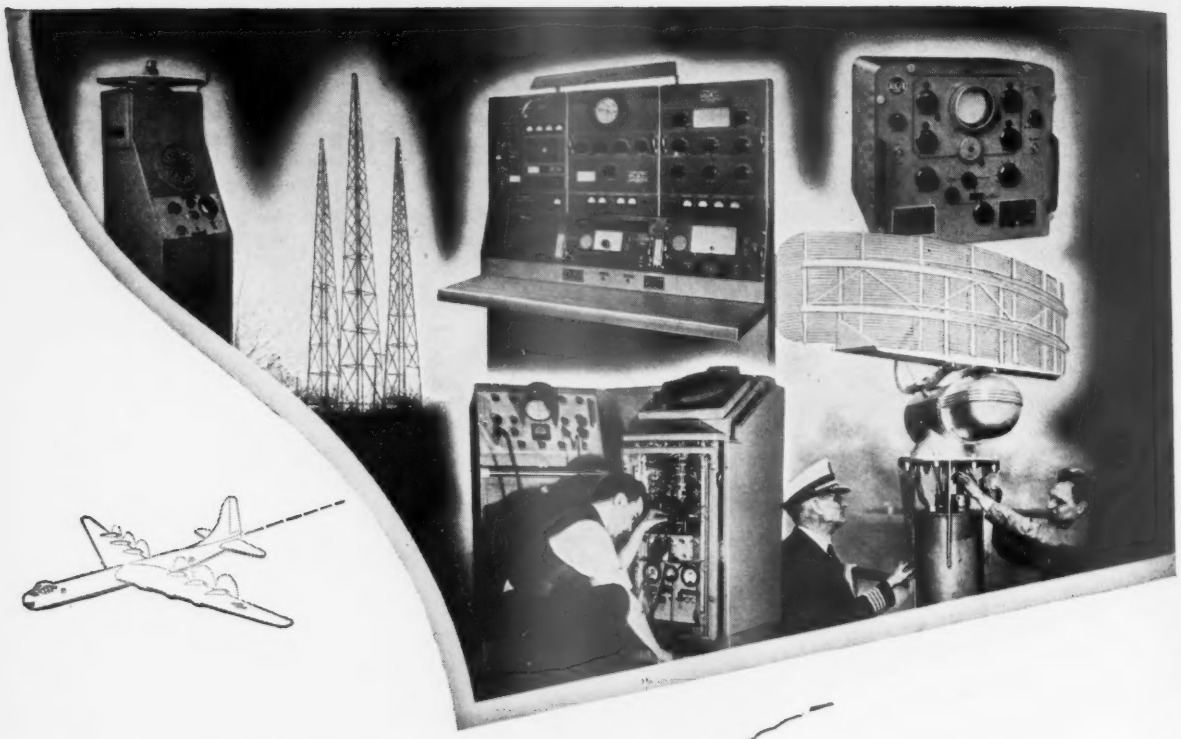

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I. A. S. News

A Record of People and Events of Interest to Institute Members

Annual Summer Meeting Preliminary Announcement

Leading Engineers and Scientists to Gather on June 27 and 28 for the Third of the Annual Summer Programs To Be Held in the Los Angeles Western Headquarters Building.

THE 1951 ANNUAL SUMMER MEETING of the Institute of the Aeronautical Sciences will get under way the morning of Wednesday, June 27, and will continue throughout the following day. As has been the custom for the preceding 2 years, the Meeting will take place in the I.A.S. Western Headquarters Building at 7660 Beverly Blvd., Los Angeles. The hosts on this occasion will be the executives and members of the Los Angeles Section under the Chairmanship of F. A. Cleveland, Research Group Engineer of the Preliminary Design Division, Lockheed Aircraft Corporation.

▸ **Technical Sessions**—Five sessions will take place during the 2-day Meeting. Those tentatively scheduled are Aerodynamics, Stability and Control, Design, Propulsion Problems in Aircraft Design, and Structural and Design Problems. Those engineers and scientists who are in attendance will be privileged to hear many of the leading experts in these given fields discuss some of the diverse problems currently confronting the engineering and scientific personnel within the aircraft industry and its allied fields.

▸ **Registration and Session Hours**—Registration will begin at 8:30 a.m. on Wednesday morning, June 27. The sessions on Aerodynamics, Stability and Control, and Design will get under way promptly at 9:00 a.m., 1:30 p.m., and 8:00 p.m., respectively. The two Thursday sessions (on Propulsion Problems in Aircraft Design and on Structural and Design Problems) will commence at 9:00 a.m. and 1:30 p.m.

▸ **Dinner**—The Annual Summer Meeting Dinner will be held on Thursday, June 28, in the Embassy Room of the Ambassador Hotel. A reception, starting at 6:30 p.m., will precede the dinner. Dinner will be served at 7:00 p.m. A prominent speaker will address I.A.S. members and their guests, and two annual awards will be presented at this time.

▸ **Awards**—I.A.S. President Lawrence B. Richardson will present The Thurman H. Bane Award and The Octave Chanute Award to their respective winners. The 1951 recipients of these awards will be announced later.

▸ **Program Committee**—Directly responsible for the planning of the 1951 Annual Summer Meeting are the members of the Los Angeles Section's Program Committee who definitely deserve the accolades of the entire I.A.S. membership for their untiring efforts in behalf of the success of this meeting. Heading this committee is Chairman Harold Luskin, Aerodynamics Research Engineer, Douglas Aircraft Company, Inc. R. Richard Heppe, Aerodynamics Engineer, Lockheed Aircraft Corporation, is Vice-Chairman. Other members of the Program Committee include: Roland L. Bliss, of North American Aviation, Inc.; Thomas F. Coleman, of Hughes Aircraft Company; Holley B. Dickinson, of Telecomputing Corporation; Harold S. Fischer, of Douglas Aircraft Company, Inc.; Welko E. Gasich, of The RAND Corporation; Frank E. Goddard, Jr., of California Institute of Technology's Jet Propulsion Laboratory; Earle S. Hodder, of North American Aviation, Inc.; Walter C. Hurty, Assistant Professor at the University of California at Los Angeles; Howard E. Roberts, of American Helicopter Company, Inc.; Manuel S. Simms, of Northrop Aircraft, Inc.; Richard B. Smith, of Douglas Aircraft Company, Inc.; and Edward J. Specht, of General Electric Company.

Copies of the final program for the 1951 Annual Summer Meeting will be mailed to all I.A.S. members.

F. A. Cleveland, Chairman of the Los Angeles Section.

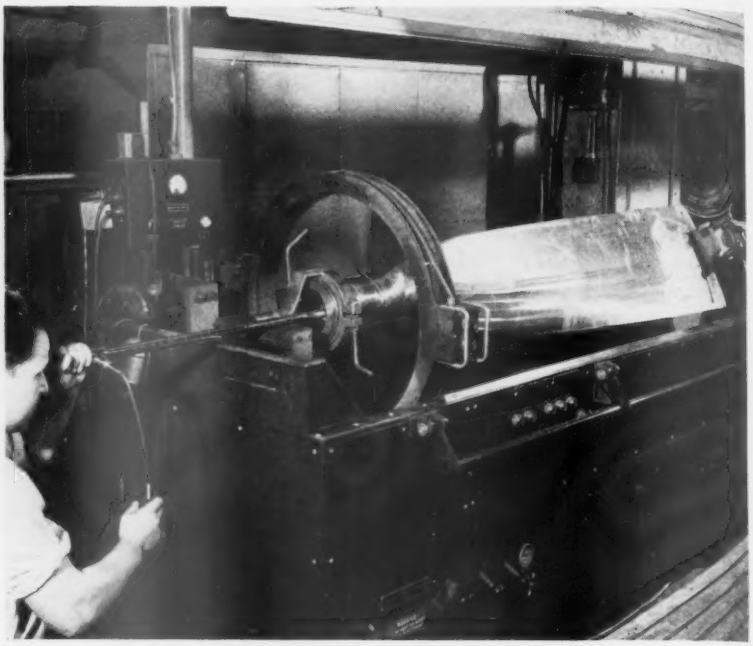
National Meetings Calendar

June 27–29, 1951 Annual Summer Meeting, Los Angeles

Propeller-Blade Extrusion Method Developed

Extrusion, hitherto confined principally to the production of piping, tubing, and other simplified forms (except in the lighter and softer metals), has now been successfully applied to propeller-blade production. Essentially, this process, developed by the Propeller Division of Curtiss-Wright Corporation in cooperation with the U.S. Air Force, imports a vital contribution to the acceleration of our National Defense program; it permits the mass production of hot extruding one-piece hollow-steel propeller blades for high-speed combat and commercial aircraft. Simultaneously, it offers the added advantages of a considerable saving in strategic materials, a reduction in essential skilled man power, the elimination of costly machining operations, and a reduction in necessary floor space and tools. As far as the blade, itself, is concerned, the improved producibility of the extruded blade is said to be accompanied by a marked increase in its quality and strength-weight ratio.

Summarily speaking, three prime operations are involved in the conversion of a billet into, first, a tube and, finally, a finished propeller blade. For the first operation, a preheated 400-lb. chrome-nickel-molybdenum steel billet is inserted into the die container of a 5,500-ton extrusion press. Here the shank of the blade is formed. The second operation returns the reheated partially formed steel billet to the press, where the shank section is tapered in preparation for the final extrusion of the propeller-blade tube. Step three completes the billet's first metamorphosis when the white-hot tube emerges, shank end first, from the press. After its removal from the press and measurements for certain tolerances taken, the tube is placed in another die where it is transformed into a Curtiss-Wright propeller blade through a heating, flattening, and forming process that lends it the proper twist and turn. Nitrogen gas, under 1,100 lbs. pressure per sq.in., provides internal support during this final transforming operation, commonly known as "blowup." The only major machining involved in this entire process is the final tooling of the propeller-blade shank.



Finishing Touches: *The only major machining operation in the propeller-blade extrusion process is the final tooling of the blade's shank end.*

The Three Stages: *A seamless, hollow-steel, propeller-blade tube, produced by Curtiss-Wright Corporation's new extrusion process, is examined by Francis R. O'Leary, General Manager, Propeller Division. The one-piece tube (center) is formed by heating and squeezing the 400-lb. steel billet (left) through a series of dies. The tube is then transformed into the finished propeller blade (right) by flattening and forming.*

This propeller extrusion process contrasts vividly with the older method by which Curtiss monocoque hollow-steel blades are also produced. The older method necessitates many welding and forming operations in order to convert two specially processed flat steel plates into a hollow-steel structure that comprises the complex curvatures and delicate balance of a completed propeller blade. One of the aforementioned advantages of the newer method over the older one—i.e., the saving in strategic materials—becomes obvious when it is considered that only 400 lbs. of steel are required for the extrusion operation while 750 lbs. of steel are needed for the older welding process. In both instances, the end product is a 200-lb., 10-ft., hollow-steel, propeller-blade tube with tapered walls.

The importance of this form of extrusion can be appreciated when its potential uses, both in and out of the aeronautical industry, are contemplated. Within the industry, things such as landing-gear struts, helicopter masts, helicopter main rotor-blade spars, etc., can be extruded. Outside the industry, this new process may be used in turning out gun barrels, tank parts, ship parts, and members for prefabricated structures such as bridges and towers.

The perfecting of this extrusion process is an outgrowth of a research program undertaken by Curtiss-Wright under the sponsorship of the Manufacturing Methods Branch of the Industrial Planning Division and the Propeller Laboratory of the Engineering Division, Air Materiel Command. The actual developmental work, however, was carried out on the equipment made available by the Air Force at the Air Force Developmental Center, Adrian, Mich.

Cooperating with Curtiss-Wright in this program were the following organizations: Hydro Press Corporation; Ford Motor Car Company; International Nickel Company, Inc.; Gerity-Michigan Manufacturing Corporation; Crucible Steel; Upton Furnace Company; Industrial City Boring Company; and Oro Manufacturing Company.

Flight Refueling, Inc., Joins I.A.S.

Flight Refueling, Inc., of Danbury, Conn., has joined those other corporations who currently hold membership in

the Institute of the Aeronautical Sciences for the mutual advancement of the art and sciences of aeronautics.

Flight Refueling was established in 1948 in answer to the needs of the United States for in-flight and ground fueling equipment, etc. Using as a basis those ideas and principles advanced by the parent company (Flight Refuelling, Ltd., of England), the American counterpart in Danbury has developed and applied this knowledge to meet U.S. requirements.

In-flight refueling systems and their components are produced for both the Air Force and the Navy. Although security regulations do not permit the full disclosure of the notable results achieved in its military applications, many advantages of in-flight refueling are available to commercial operators.

The utilization in aircraft of this particular technique of in-flight refueling is said to provide greater safety, longer ranges, and higher pay loads and to reduce substantially direct operating costs. A number of publications pertaining to this subject have been prepared by various authorities and are available on request.

Flight Refueling also produces a high-speed ground pressure-fueling system and the corresponding equipment. This type of system is claimed to permit rapid fueling of aircraft, thus offering a real saving of turn-around and "idle" time.

Danger of Skidding Removed from Landings

Two new devices developed by the Air Materiel Command are said to eliminate the skidding of aircraft regardless of the amount of pressure applied to the brake pedal.

These devices, the "brain children" of Westinghouse Electric Corporation and Boeing Airplane Company, are both based on the same principle: ability to sense a skid and to release brake pressure automatically until the skidding condition ceases by virtue of a valve that shuts off the pressure to the brake drum. However, in their essential details they differ distinctly.

One of the inventions is the Hytrol, designed by Boeing and manufactured by Hydro-Aire, Inc. This particular design employs a skid detector and a solenoid valve. The second of these is known as the Decelostat and is being manufactured by Westinghouse. This latter invention is based on the relative speeds of the undercarriage wheel and an energy wheel.

The Hytrol and the Decelostat are being tested on the Boeing B-47 and Martin XB-51 jet bombers. Installation on the Convair B-36 and certain cargo and fighter aircraft is planned.

Necrology

William H. Graham, Jr.

William Henry Graham, Jr. (M.), died on March 3 as the result of a take-off accident from the deck of the aircraft carrier, U.S.S. "Princeton," lying off the East Coast of Korea. He had been sent to that general area a short time before as a correspondent under the joint auspices of the Air Force, aircraft manufacturers, and *The Journal of Commerce* of New York. He had planned to present lectures to the Air Force personnel based on his own observations with the U.S. Air Lift.

Bill Graham was Associate Editor of the AERONAUTICAL ENGINEERING REVIEW during 1941 and early 1942. He left the Institute in March, 1942, to become Technical Air Information Officer and Publications Officer with the rank of Captain. His assignments for the next 4 years were primarily in technical public relations and intelligence and in planning and policy relative to technical activities and programs of the Army Air Forces. He was discharged in 1946 with his majority.

After a year of free-lance work, Bill Graham joined the Air Reduction Company as a Technical Writer and Promotion Specialist. In 1949, he became Editor and Engineering Analyst for the analyses, critiques, and reports by American Power Jet Company. Late in 1950, he accepted the post of Aviation Editor on *The Journal of Commerce*, a New York business newspaper, and, commencing with the December 7 issue, he wrote a daily column for the paper entitled "Air Headings."

Born in South Charleston, Ohio, on June 30, 1911, Mr. Graham was educated in the public schools of Springfield, Ohio, and after 4 years at Oberlin (Ohio) College was graduated in 1931 with a B.A. degree in History and Political Science. He also attended Princeton University, New York University, and the University of California. He was a graduate of the Air University, the Air Command and Staff School at Maxwell Air Force Base, Ala. He is survived by his 6-year-old son, William H. Graham, III, and his widow, the former Gwendolyn Lloyd, who prior to her marriage was a librarian at the Institute. Bill Graham was a Senior Member of the Aviation Writers Association.

George T. Weems

Lieutenant Commander George Thackray Weems, U.S.N. (M.), died of injuries received in an airplane crash on January 16. The accident occurred during the take-off of a seaplane, in which he was riding as passenger, from the Delaware River near Newcastle, Del. An urn containing his ashes was buried on April 5 at the Naval Academy cemetery while naval flags were lowered to half-mast.

Born in Annapolis, Md., on January 5, 1921, Commander Weems was the son of Capt. P. V. H. Weems, U.S.N. (Ret.), F.I.A.S., who was the founder of the Weems System of Navigation. The younger Weems, planning to make the Navy his life's career, was appointed to the U.S. Naval Academy in June, 1938, as a Midshipman. He was graduated with a B.S.E.E. degree in December, 1941, approximately 2 weeks after the attack on Pearl Harbor.

Commander Weems played an active part both as Pilot and Project Officer in the various flight tests that were conducted on carrier-type aircraft.

In addition to holding a C.A.A. Commercial Certificate No. 522668, Commander Weems was a Naval Aviator in active flying status, qualified to pilot single- and multiengined, land- and sea-based, and reciprocating- and jet-powered aircraft. He started his flight training in May, 1943, and by the end of World War II had built up an outstanding combat record as a fighter pilot. He is credited with shooting down four Japanese planes. For service to his country, he was awarded the Silver Star Medal, the Distinguished Flying Cross and a gold star, and the Air Medal and four gold stars.

Commander Weems was a member of the Institute of Navigation and of the Naval Institute.

(I.A.S. News continued on page 64)

Electronics in Aviation

A Guest Editorial

by

CAPTAIN S. B. SPANGLER, U.S.N.

Commander

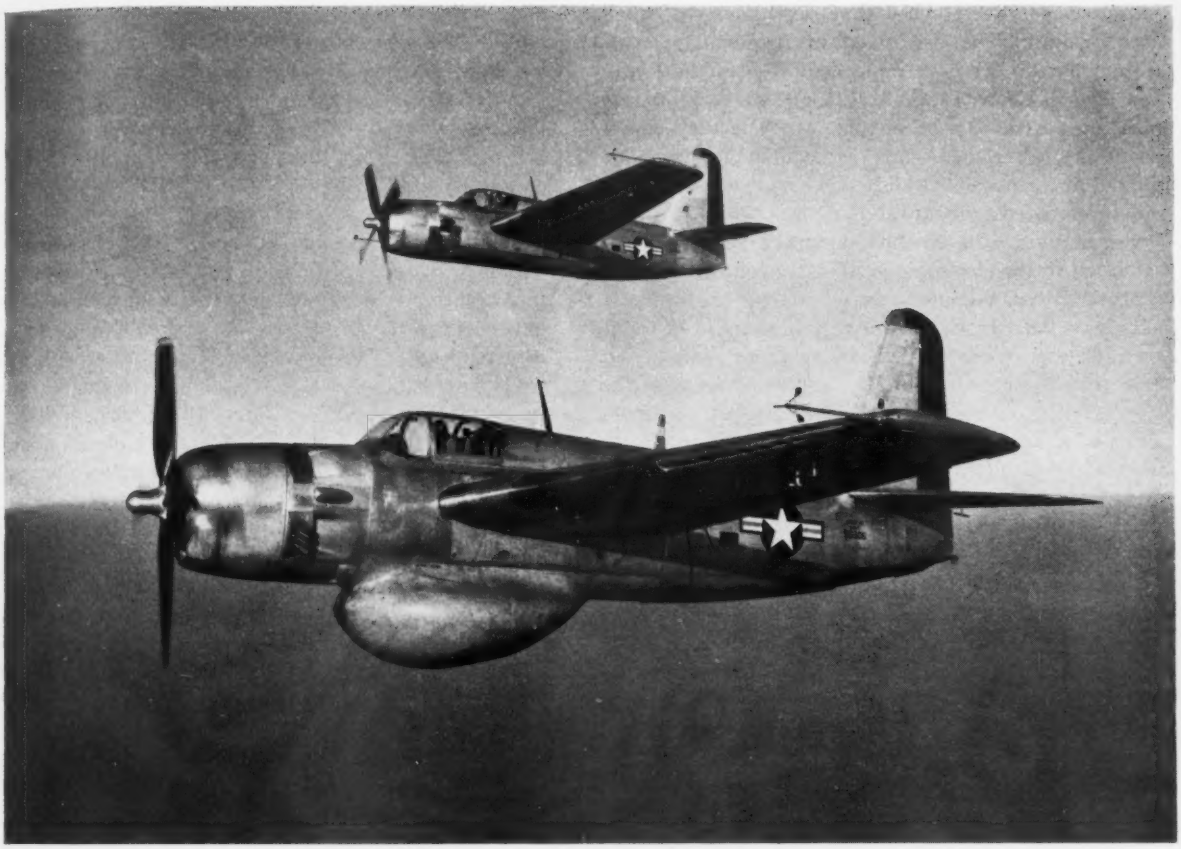
U.S. Naval Air Development Center

Johnsville, Pa.

Captain Selden Booth Spangler, U.S.N., has had broad experience in the Navy both as pilot and aeronautical engineer. A 1923 Annapolis graduate, he has been a Navy pilot since 1925 and has spent many years on flying duty. Upon concluding an aeronautical-engineering course leading to an S.M. degree from M.I.T., he was appointed Assistant Superintendent, Aeronautical Engineering Laboratory. Eleven of his 32 years in the Navy were with BuAer's Power Plant Division of which he became Head in 1939. Seven years later, he was made Chief of the Aircraft Maintenance Division, BuAer. His present assignment began in July, 1950. Captain Spangler is a Fellow of the Institute.

ON MY FIRST CATAPULT SHOT as an observer from a battleship some years ago, I was both amazed and surprised to find the radio set in my lap as we left the end of the catapult. This incident engendered in my consciousness a distaste for all things electrical and electronic which persisted for a great many years. Being a power-plant man, I came to look on radar and communication systems as intended primarily to raise the power loading beyond a reasonable or efficient level or to place operating conditions on the airplane fiendishly devised to force the engines to operate under the most unfavorable conditions. It was clearly evident that an airplane could not operate without a power plant very successfully very long. In fact, it had been my proud boast that with two turkey feathers and a snow shovel one could sit on a five-gallon gasoline can and fly a bare engine from here to there with little trouble. On the other hand, radio only served to while away the long hours it took to burn up the gasoline supply, and radar was something that presented an amusing picture of a small white bug crawling over a glass surface and by whose antics the operator could state (subject to visual proof, of course), that something existed somewhere in the general vicinity.

Three incidents occurred thereafter, however, which led by degrees to: first, a suspicion that there might be



some faultiness in my reasonings; second, a thought that maybe radar really had something; and, third, a realization that no longer was the engine the only really essential part of the airplane. In the first case, after a somewhat uneventful trip as a passenger in one of our aircraft, we arrived over our landing point only to be told that there was a heavy fog drifting in and that the ceiling was already down to three hundred feet with a visibility of one mile. Much to my surprise the pilot only yawned slightly and, after some radio conversation, started down through the fog. Just as I was about to pull the release on the emergency door, we broke out, nosed up slightly, and sat down in the middle of the approach end of the runway. After my heart stopped pounding so hard, I asked the pilot how he did it, and his answer was to give the simple but cabalistic reply, "GCA." I found out later by personal experience that it really was almost that easy.

The second incident occurred off Okinawa. About one o'clock one morning of a particularly black and nasty night, the Combat Information Center (CIC) reported two enemy aircraft making what appeared to be a torpedo run on the starboard quarter distant about eight miles. Three minutes and some one hundred rounds of five-inch ammunition later, there were two beautiful pyres of flame astern. For the next two weeks, I spent all my free hours in the CIC watching with utter amazement the accuracy of discovery, positioning, and interception of enemy attacks. Finally, I was ordered to my present position in which I have had the opportunity of seeing what is being and can be done. Having thus become an enthusiastic convert perhaps I can rub off on some of you airplane people a little of that enthusiasm.

I realize only too well that it frequently appears to uninitiated that the electronics man considers an airplane only as an aching void in which to shoehorn equipment of various and unwieldy shapes and sizes and that the airplane man looks on electronic equipment as a plethora of heavy and rather touchy black boxes that seem intended and destined to ruin his pet's performance. Actually, however, neither view is fully sound, although it is quite true that the electronics man could use some more knowledge of the airplane and the airplane man a better understanding of the electronic gear.

Nor would it be quite fair to say that no attempt has been made to bring together the apparently incompatible ideas of the aircraft designer and the electronics expert. Some years ago the electronics engineers realized that it was poor business to present electronic equipment in odd packages of all shapes and sizes.

An agreement was reached that electronic gear, when possible, would be assembled in rectangular cross-section boxes that were multiples of a standard size, and the "ATR" or "SAR" rack (standard aircraft rack) appeared. To be sure, no one was very happy about the form factor, and rectangular cross sections did not fit the normal aircraft skin shape, but the whole idea represented a forward step.

Furthermore, the aircraft designers began to pay attention to the electronic problems, particularly those concerned with the antennas. Antennas are not amenable to standard rack treatment, their shape is, to a considerable extent, dictated by propagation requirements, and they cannot be entirely concealed within the metallic skin of an aircraft. The aircraft designers are now usually giving consideration to the needs of radome placement, communication antenna placement, etc., taking advantage of the fact that new electronic antenna developments permit structures that add no, or slight, drag to the basic aircraft design.

Advances in electronic art continue to improve the prospects for the future. Miniaturization is making revolutionary strides that, when the research and development work evolves into production equipment, will greatly improve the storage problem. The chances are that the electronic maintenance man of the 1930's will have difficulty even identifying the component parts of electronic equipment that will be in common use during the next ten years.

Perhaps an even more important factor to consider is that in these days almost every characteristic of the military airplane is affected by the electronics that it is to carry. Let us take the moderately complex case of the ASW scout airplane, the one that is intended to find and fix the position of the submarine. Such an aircraft should be able to locate a surfaced or snorkeling submarine at a reasonable distance through what is called clutter or sea return, clutter simply being the blanket return one gets on the radar scope through reflected waves from the ocean's surface and through which a target may be completely indistinguishable. Normally, this blanketing of the scope is a maximum near the center of the scope or closest to the searching airplane. Thus, one might see the surfaced submarine at fifty miles and yet be totally unable to see the same target at twenty from the same altitude. Since this sea return is a function of altitude, the lower the search airplane flies, the shorter the range at which the target becomes indistinguishable. On the other hand, since radar is a line of sight device, the lower the airplane flies, the shorter the range at which it can see at all. Let's see then, what this particular characteristic does to an airplane.

If it is assumed that nothing can be done about this particular effect and since it is reasonably obvious that one should attempt to detect the submarine at the maximum (within reason) distance from your own ship, we have defined an airplane with maximum range at or near sea level. This automatically dictates a choice of wing loading, power loading, span, and engine most suited for that altitude. For one thing, we have almost certainly eliminated any consideration of a turbojet engine and would be smart to reduce the supercharging of the engine to the minimum consistent with desired take-off power. Again, assuming we desire to search an area one hundred miles in advance of the vessel and to a safe distance each side of the vessel's track and that we are restricted to such an altitude that the radar range is twenty-five miles, we need a minimum of two aircraft with a cruising speed of one hundred fifty knots, possibly only one if its cruising speed were over two hundred knots.

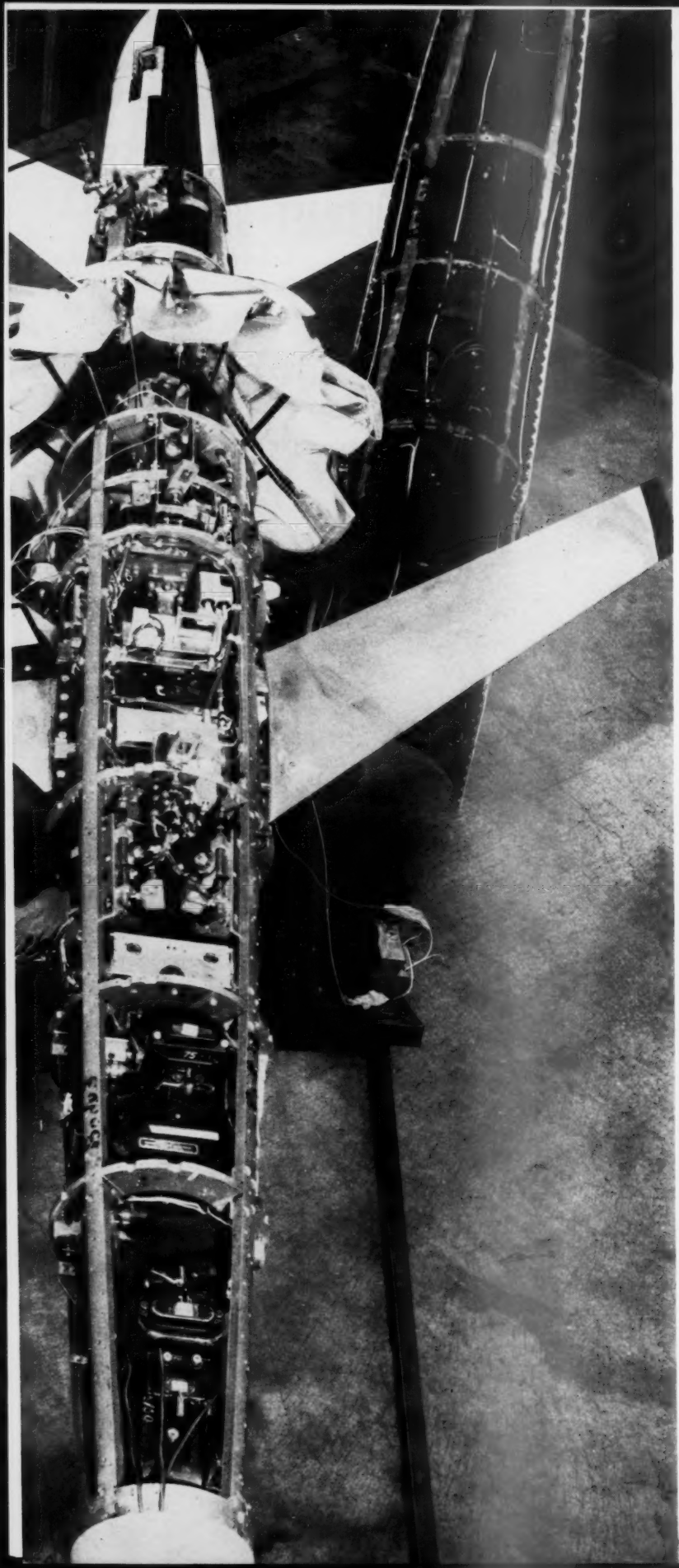
On the other hand, were it possible to see with clarity all targets from zero range out to one hundred miles, we could now fly one airplane at 10,000 feet, for this airplane cruising speed has no value although we should like maximum endurance. Therefore, we must now again select a somewhat different power loading, wing loading, span, engine, and perhaps even wing form. Here we might feel thoroughly justified, for example, in picking an engine with a very low specific fuel consumption even though the basic engine were much heavier.

While this is a great oversimplification of a complicated problem, it gives some indication of the fact that the design of the airplane is in many cases wholly dependent on the capabilities of the electronic gear, predicated for the time the airplane is to be built. Conversely, of course, the electronics man must make every effort to simplify the airplane designers' problems by furnishing equipment that can meet the specific tactical problems for which the airplane is designed.

ELECTRONICS INFLUENCES AIRCRAFT DESIGN

The influences of electronics on aircraft design become immediately apparent when we glance at any modern military plane. The long nose sections, streamlined probes, domes, and pods are necessary appendages that usually serve but one useful purpose—the housing and operation of electronic equipment.

From the standpoint of aerodynamic efficiency, it is obvious that the aircraft designer and the electronics engineer must each have an understanding of the other's problems.



ELECTRONICS FOR AIRCRAFT Illustrated

by
WELMAN A. SHRADER

Like the tail that wagged the dog, ele
tronics bids fair to become the appenda
that controls the aeronautical engineer.

The days of designing airplanes for t
sake of the plane alone are past. N
longer can we accept an aircraft simply b
cause it flies well and then start lookin
around for places to hang the gadget
The gadgets are becoming far too comple
and too numerous.

Individual electronic components—
whether they be navigational aids, radi
bombsight computers, engine controls,
automatic pilots—can no longer be co
sidered as separate instruments to be stu
into just any available space. The inti
relationship and interdependency of a
such components—from the power-sourc
to their respective operations—demand
that they be considered as a "system."

This "system concept" has caused t
air-frame manufacturer to go into the el
tronics business, establish his own researc
and engineering departments, and ini

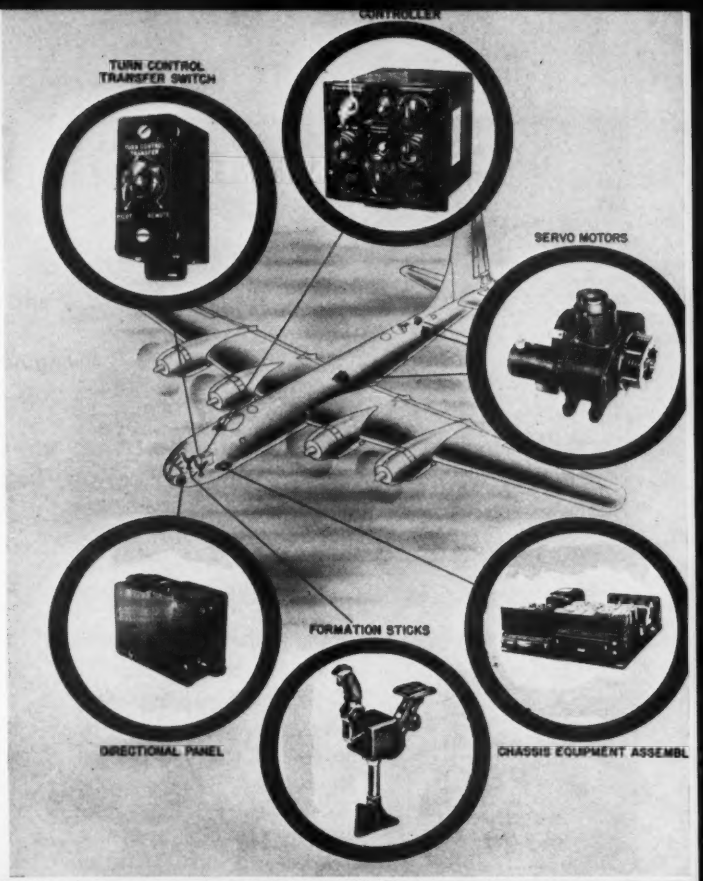
**A free-falling "body," utilized by t
Ames Aeronautical Laboratory, N.A.C.A
for research on the problems of transo
flight, is literally "stuffed" with electron
instruments that will automatically reco
data during the descent.**

Photo Courtesy N.A.C.A.

grate the ever increasing number of electronic instruments and controls into systems that are compatible with basic aircraft design theory.

Although most of the present work on guided missiles and electronically controlled aircraft is "Classified," the pictures of earlier models shown here clearly illustrate the predominant role played by electronics today.

(Continued on page 16)

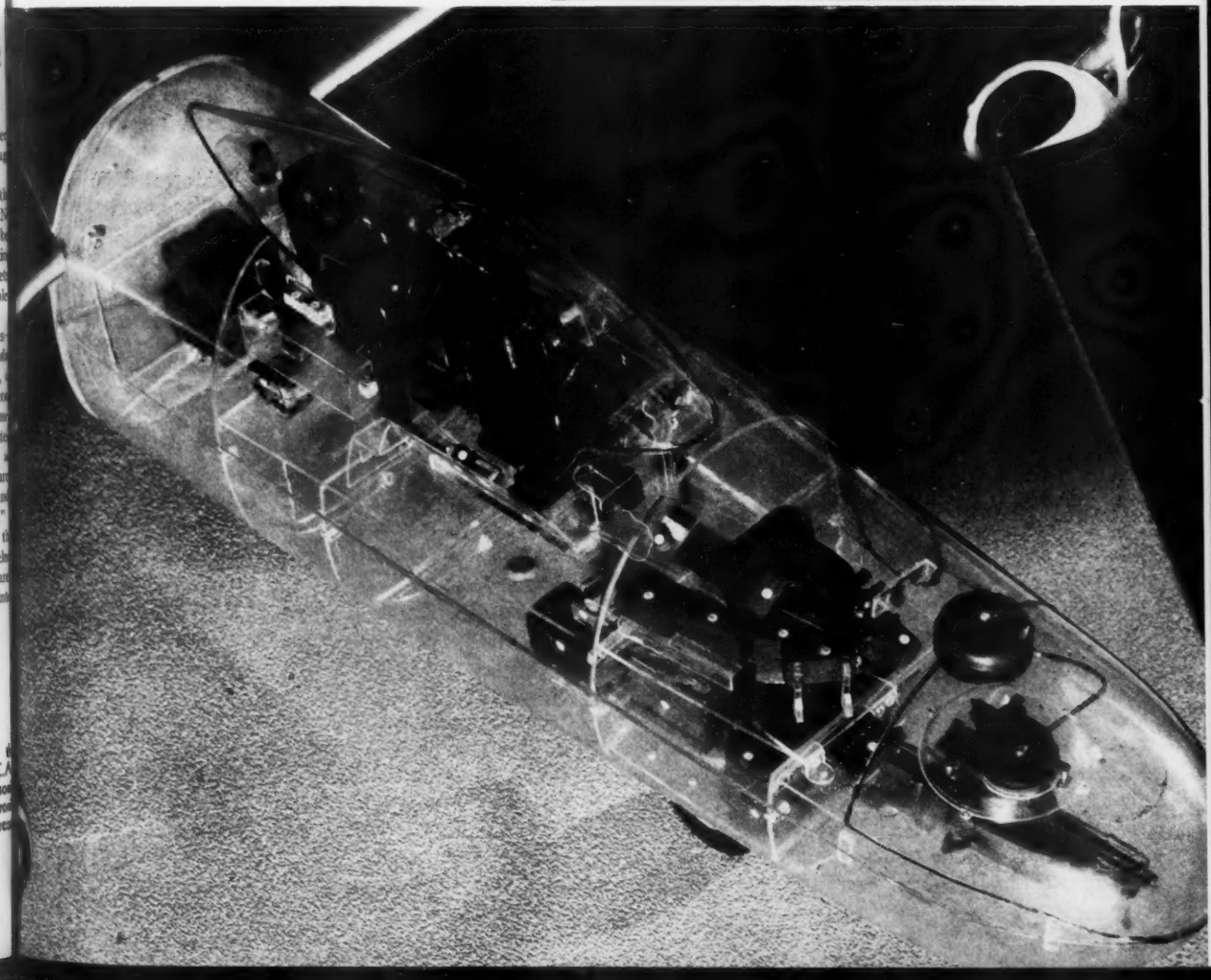


This complete Honeywell Electronic Autopilot is typical of one of the many electronic "systems" that has to be incorporated in a military bomber.

Photo Courtesy Minneapolis-Honeywell Regulator Company

Scale wooden mock-ups of all the electronic equipment contained in the nose of a B-45. This plane carries approximately 2,800 lbs. of electronic equipment, of which roughly 75 per cent is located in the nose section.

Photo Courtesy Air Materiel Command



Electronics in Aviation

HAROLD A. KRESSLY and JOHN S. ERICKSON

Grumman Aircraft Engineering Corporation

A Summary of the Morning Session on Electronics at the I.A.S. Nineteenth Annual Meeting, February 1, 1951

Harold A. Kressly.

THE RAPIDLY INCREASING IMPORTANCE of electronics in the design and operation of aircraft was the keynote of the joint meeting with the Institute of Radio Engineers and the Institute of Navigation which took place on the last day of the Annual Meeting of the Institute of the Aeronautical Sciences. As an item now accounting for 10 to 25 per cent of the design and production costs of current aircraft, electronic developments and their implications for air-frame manufacturers were underlined by each of four papers covering various aspects of aviation problems originating from this source.

From the paper given by Edwin Lee White, of the Federal Communications Commission (see page 38), it seemed clear that the first problem to be considered before any specific aircraft electronics systems could be designed was the allocation of frequencies for radio and radar operations of all types. The frequency spectrum is in itself a natural resource, subject to physical limitations as finite as those of such other more tangible resources as minerals or land. Thus, recent increases in the use of electronics—not only for normal communications but for landing, navigation, and other radar aids—have crowded spectrum space to a point where available frequencies are now far exceeded by the demand. While every effort is being made to solve this problem by allocating desirable frequencies on an equitable basis and by reserving the bands suitable for long-range operation for safety and public-benefit services, aviation is the only interested group that has thus far agreed on a workable plan. It was Mr. White's feeling, however, that, even with optimum allocations and optimum plans and agreements, some supplementary solution must be sought. The most promising field for such a solution appears to be in the development of multiple-function equipments and equipments capable of operating on narrower or previously unusable bands.

John S. Erickson.

The progress made to date in using the presently allocated frequencies to implement the Common System of Air Navigation was summarized by Charles Banks, of Aeronautical Radio, Inc. (see page 24) The Common System—which is in its own way unique—is so called because it was devised jointly and empirically by all aviation interests in the United States, Government and private (as represented by Special Committee 31 of the Radio Technical Commission), to meet the common need for reliable use of all airspace by all aircraft in all weather. Originated in 1947, the plans for this system are divided into two programs: a transitional program, which will come into general use around 1953; and an ultimate program, which is scheduled for completion in the mid-1960's. Mr. Banks estimated that funds amounting to at least 25 times the sum thus far spent for present low-frequency four-course ranges must be expended before this project as a whole is complete.

The corresponding changes in aircraft requirements were graphically illustrated when Mr. Banks pointed out that the interim system alone requires twice the number of equipments needed for the old low-frequency range system and that, whereas ten-channel voice communications were usual at the end of World War II, as many as 360 channels will be available when the Common System is complete. At the present time, equipment with 180 channels is available and in use. As a rule, at least 3 years are required to produce any of the complex equipments used for the Common System, and 2 additional years are required to effect their general installation in operating aircraft.

Specific problems in developing electronic equipments for aircraft applications of this System were discussed by Orville M. Dunning, of the Hazeltine Electronics Corporation (see page 29). Aside from the basic need for equipment packaging to be standardized, light in

weight, and small, Mr. Dunning felt it important that access be available for the mechanic with a little ingenuity and a soldering iron to make at least minor repairs. This would indicate some departure from present trends toward "potted" subunits, which often must be discarded because of the failure of a single simple component or other reasons of a minor nature.

By using the miniature tubes and components available today, it is possible to reduce most equipments to something like one-half their former size. As all air-frame designers are aware, however, this decrease in overall size has been more than counterbalanced by the increased number of equipments that must now be accommodated within the limited air-frame space. It seems time, therefore, to take subminiature techniques out of the laboratory (where they have remained, somewhat inconclusively, for the past 5 years) and apply them to production units for general aircraft use. This would permit a quantitative trial of the techniques thus far developed, while revealing the information necessary for further advancement. Two of the most immediate problems to be solved in connection with any application of miniature and subminiature techniques would be the development of adequate cooling methods and the development of comparably scaled hardware components.

The role of the aircraft designer in cooperating directly with the electronics equipment designer was emphasized by Harold Schutz, of The Glenn L. Martin Company, who spoke of aircraft radio and radar systems design (see page 32). Mr. Schutz pointed out that, whereas it was once possible to install electronics systems without particular reference to the air-frame configuration, the growing use of aircraft as electronics platforms and the consequent need of finding the ideal compromise between aerodynamic and electric considerations have now combined to make joint solutions essential. This is especially true in the case of military aircraft, whose ability to accomplish a mission successfully and safely has now become as dependent upon proper performance of the electronic devices for navigation, identification, target-sighting, and communication as upon speed and maneuverability.

Of all the components in aircraft electronics systems, the antenna presents the most critical problem, Mr. Schutz said. While considerable progress has been made in adapting all basic antenna types to air-borne use, the increased number of equipments in use and the streamlining required on new high-speed aircraft have complicated the original difficulty of finding operatively acceptable locations within the available space. Added to these complications are the fundamental physical laws that limit design possibilities for antennas and the fact that a basic design will not necessarily give equivalent performance on different aircraft configurations. From present indications, the most promising possibility for a solution appears to be the use of portions of the basic air frame as the antenna. In Mr. Schutz's opinion, however, tolerable antennas are probably the best that aviation can hope for, since the invariable tendency of the air-frame manufacturer is to freeze the antenna design, once moderately adequate electronics performance is attained.

Electronics in Aviation—Panel of Speakers. (*Left to right*): *Chairman, D. S. Little, Supervisor, Airway Aids, American Airlines System; Charles R. Banks, Chief Engineer, Aeronautical Radio, Inc.; Orville M. Dunning, Vice-President—Engineering, Hazeltine Electronics Corporation; Harald Schutz, Head, RF Engineering Section, The Glenn L. Martin Company; Edwin Lee White, Chief, Safety and Special Radio Services Bureau, Federal Communications Commission.*

Equipment Reliability

It was clear from the gist of these various talks that, in order to compete reasonably with others in his own field, the aircraft manufacturer must from now on consider his electronic problems at the initial design stage of the air frame and must solve these problems concurrently with such other basic problems as propulsive power and aerodynamic performance. However, one topic of prime interest to aircraft manufacturers, and to operators as well, was not mentioned at all, possibly for lack of time. This topic was equipment reliability, a field in which considerable progress has been made and in which much more is desirable. A striking example of what has been, and what can be, accomplished in the way of reliability is illustrated by the recent A.R.I.N.C. program on "ruggedized" tubes. Introduced on commercial air lines in 1949, the "ruggedized" tube reduced tube failures of certain types from 30 to 2.5 per cent for the first thousand hours of operation, thus saving an estimated $250,000 in operative costs for the year 1949, despite a much higher unit price than the conventional tube. The increase in flight safety resulting from this change was even more important though, of course, less measurable. Expansion of the ruggedizing program to cover other critical components should be a basic consideration in all new electronic equipment design and would make a profitable topic of discussion for future meetings of the Institute of the Aeronautical Sciences.

ELECTRONICS FOR AIRCRAFT

(Continued)

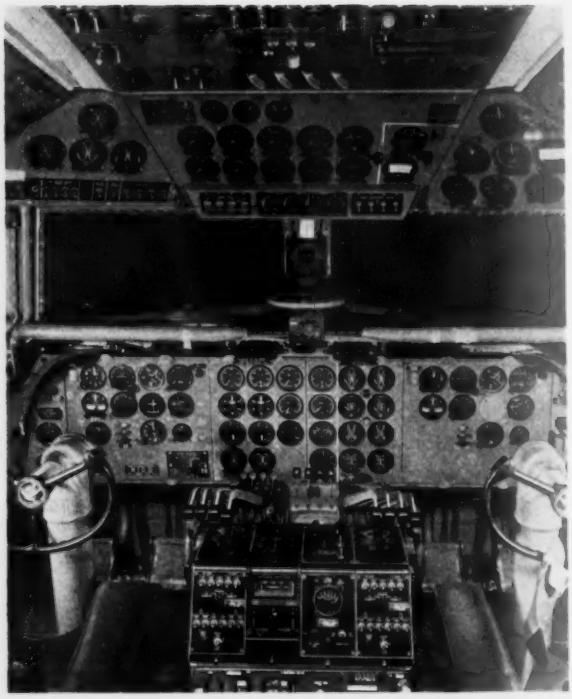
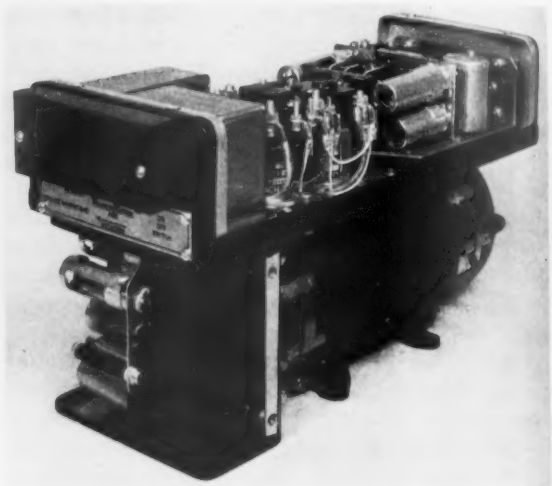


Photo Courtesy American Airlines and The Sperry Corporation

The pilot's cockpit of a modern air-line transport where the workings of the various electronic installations are controlled and interpreted.

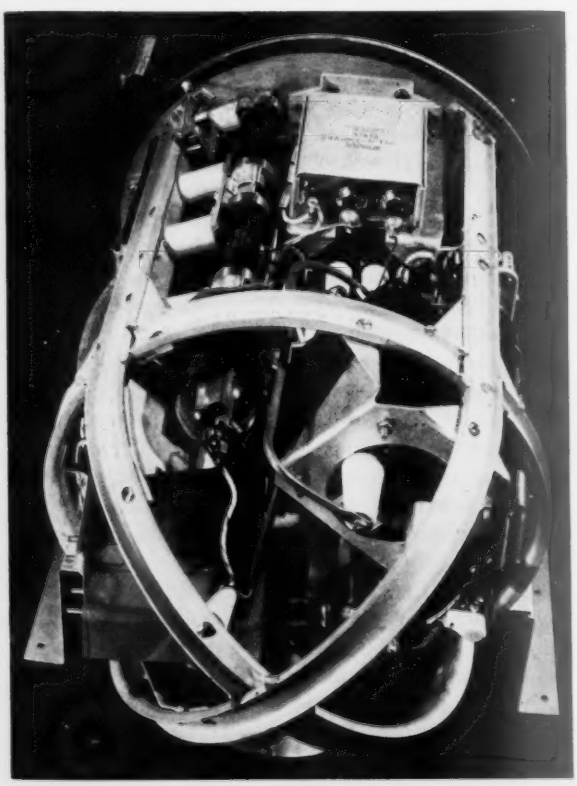
INSTRUMENTS AND CONTROLS

There appears to be no end to the things that can be accomplished in, and for, an aircraft through electronics. Whether the problem is one of locating the landing field, intercepting a high-speed enemy fighter in pitch darkness, dropping a bomb on a target from 40,000 ft., or simply wiggling the tail of a 200,000-lb.

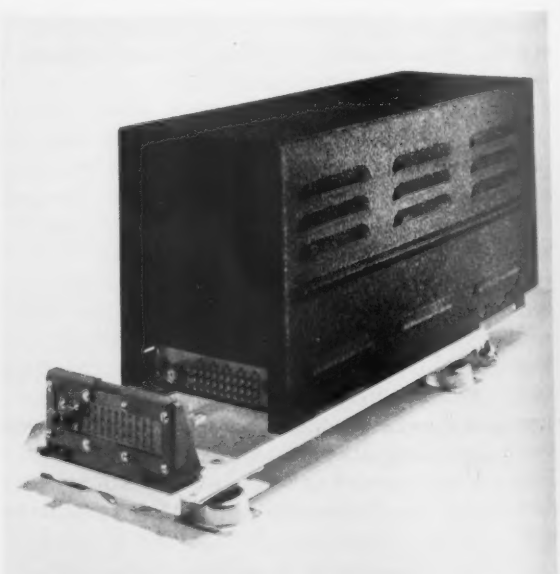


The output of constant a.c. voltage for operating aircraft radio, radar, and other accessories calls for a dependable air-borne Inverter. This particular model is one produced by Jack & Heintz Precision Industries, Inc.

A high-power pulse transmitter pressurized for air-borne application, developed by The Glenn L. Martin Company.



Compact model Curtiss Electric Propeller Synchronizer has automatic electrical and mechanical plug-in feature in self-contained unit. View shows unit about to engage connection.



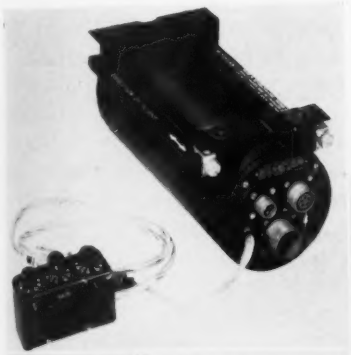
airplane in flight, there is a series of vacuum tubes somewhere to accomplish it. All that appears necessary is to push a few buttons or throw a switch.

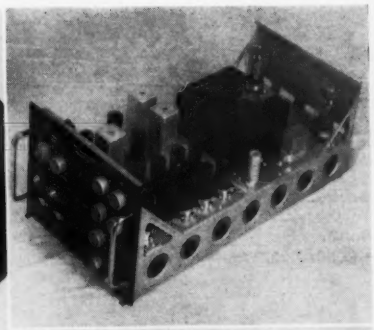
As yet, we have only scratched the surface of developments in this field. Research conducted by hundreds of individual electronic companies is daily uncovering new applications, new techniques, and new products that change the airplane's complexion and broaden its uses.

Pictured here are but a few of the many diversified types of electronic controls and instruments used in aircraft today.

(Continued on page 22)

(Right) Electronic Positioner, which ties in with a Synchronizer being used in aircraft throttle control systems, developed by AiResearch.

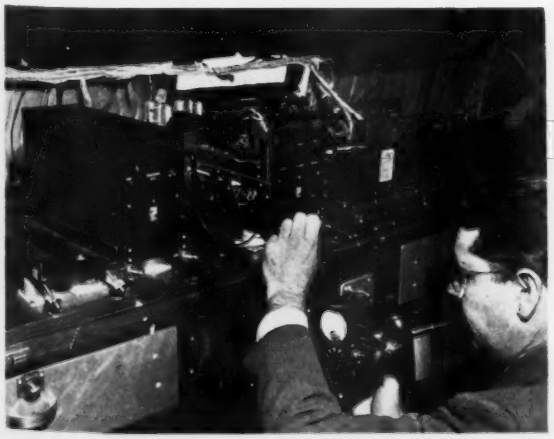




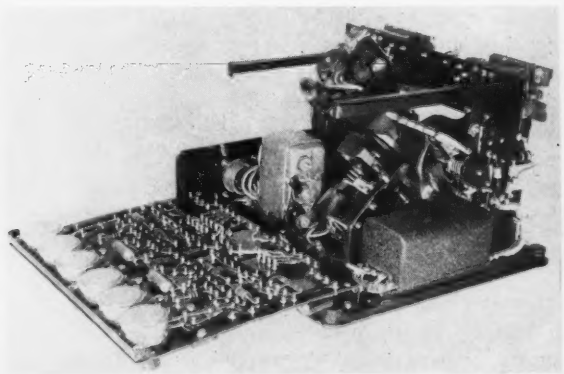
(Below, upper right) A Convair-manufactured Video Amplifier helps operate five auxiliary radio-altimeter indicators functioning from the output of one radio-altimeter transmitter-receiver. (Below, lower right) Electronic temperature control panel for aircraft developed by Westinghouse Electric Corporation.

(Upper left) Electromechanical dampening control produced by Lear, Inc. (Lower left) The Sperry Zero Reader, consisting of three units, translates the various rate-measuring instruments into a "plan of flight" for the pilot. (Center) A Fuel Flow Totalizer Indicator, produced by Eclipse-Pioneer Division of Bendix, gives continuous indication of rate of fuel consumption and amount remaining in tanks.

The "back-stage" electronic equipment for a new Automatic Approach, Landing, and Cruise System for Navy aircraft is checked by a Minneapolis-Honeywell Regulator Company engineer.



A complete automatic pilot system (exclusive of servomotors) designed for the stabilization and control of uninhabited aircraft by Doelcam Corporation.



L. W. Burton, Jr., Secretary, Air Traffic Control and Navigation Panel of the Air Coordinating Committee, who delivered this address. Mr. Rentzel was unable to attend the luncheon because of illness.

Air Traffic Control

By
The Hon. DELOS W. RENTZEL*

I.A.S. Annual Meeting
Luncheon Address
February 1, 1951

"I AM MOST APPRECIATIVE of the honor attending your invitation to me to speak before this Joint Assembly of the Institute of Aeronautical Sciences, the Institute of Radio Engineers, and the Institute of Navigation. The professional and scientific knowledge represented here today has played a large part in the creation of the present great air power of the United States.

"American aeronautical engineers have provided this country with the finest, fastest, and most versatile aircraft in the world. The science of navigation has made it possible to move these aircraft throughout the world to any point desired with accuracy and regularity. The science of radio and electronics has added to the navigational capabilities and further—of utmost importance—has made possible communications and control to the degree required for a large-scale air operation, including the movement of various aircraft under dense traffic conditions in almost any kind of weather.

"Today we are in a state of national emergency. We are engaged in the mobilization of the resources of this country in order that we will be able to cope with whatever dangers threaten our security. At such a time, U.S. air operations *must not* be limited by any controllable factor.

"The total potential air lift in the event of a national emergency may be limited by aircraft availability, but it *must not* be restricted by an inadequate air-traffic-control system. Under emergency conditions, the necessary mass movements of military aircraft throughout the United States *must not* be hindered by traffic-control factors.

"Safety in congested air traffic is of prime importance to both military and civil users. Military, as well as civil, traffic collisions must be prevented even in times of war. The costliness and logistical value of present-day military aircraft and crews has become a primary consideration in itself.

"At this point I should like to give you a brief bit of background information In 1947, American aviation authorities took action with regard to one of its major problems. Constantly increasing U.S. air operations were attempting to function with an outmoded system of navigation and traffic control which had been in existence for a number of years prior to World War II. Actual movement of aircraft was so limited by weather and traffic congestion that delays and missed connections were costing the public and the air lines many millions of dollars annually. It was retarding the growth and development of U.S. air commerce and—of even greater importance to us today—restricting the movement of military air traffic.

"The Air Coordinating Committee recognized the seriousness of this situation at that time and, as a matter of immediate action, requested the Radio Technical Commission for Aeronautics to undertake a study of the

* Chairman of the Air Coordinating Committee and of the Civil Aeronautics Board.

problem. As all of you know, the R.T.C.A. came forth with a general plan, the SC-31 report, as a basis for a common system of air navigation and traffic control.

"In accordance with the recommendations of the SC-31 report, the Air Coordinating Committee then set up a steering and coordinating body named the 'Air Traffic Control and Navigation Panel.' This Panel was given authority to act in the name of the Air Coordinating Committee on matters of policy, procedures, and operational requirements for the Federal Airways system.

"At about this same time, the Air Navigation Development Board was established. Its task was to see to such further development as might be necessary for certain Transition Period equipment and to carry on the extensive research and development necessary to the achievement of an ultimate system as envisaged by the R.T.C.A. SC-31 report.

"The Civil Aeronautics Administration had also been busy. The Office of Federal Airways was well along with its program of installing a highly improved electronic short-distance air-navigation system.

"U.S. air operations began to improve. By 1949 they had improved extensively. Real progress has been made during the past several years in developing and implementing the Common System.

"However, aircraft movement requirements continued to increase. Traffic congestion became worse in already congested areas, and congestion began to spread to other areas. Despite improvement in operations and procedures, it became clear that inadequate air-traffic-control equipment and traffic congestion, aggravated by bad weather, was still the most important limiting factor in our air operations.

"Thanks to you professional men, the electronic tools—such as radar, weatherproof communications, ranges, beacons, and other associated devices—for doing this job were available. The Air Traffic Control and Navigation Panel found that the obstacle that confronted it was a problem of detailed coordination so vast in nature that unusual steps would have to be undertaken to set forth successfully the detailed blueprint that would combine the best technical know-how, the most up-to-date operating procedures, and the most modern equipment into an integrated system that would lend itself to immediate implementation.

"To provide a method for obtaining this coordination, the NAV Panel sought the authority of the Air Coordinating Committee to establish a *full-time* Operational Policy Group comprised of top-level technical and operational people of both Government and industry. The Panel specified that the task facing this Policy Group was of such magnitude that the Group should remain in continuous session until its work was completed.

"This Operational Policy Group quickly commenced its work and, with no great surprise, found its problem to be *most complex*. A most important facet of the problem was to discover and integrate the various facts and opinions necessary to give to the system plan the thinking of all available sources and to provide the coordinated system with the support of all elements of aviation, thus making it acceptable to all users of the airspace.

"This rather large order involved coordination *within* individual Government agencies, coordination *between* Government agencies, coordination *within* industry, coordination *between* Government and industry, coordination *between* the technical and the operational people, coordination *with* the developmental agencies, coordination *with* agencies of special interests—such as the Air Defense Command—and, finally, as thorough a coordination *throughout* the realms of U.S. aviation as was practicably possible.

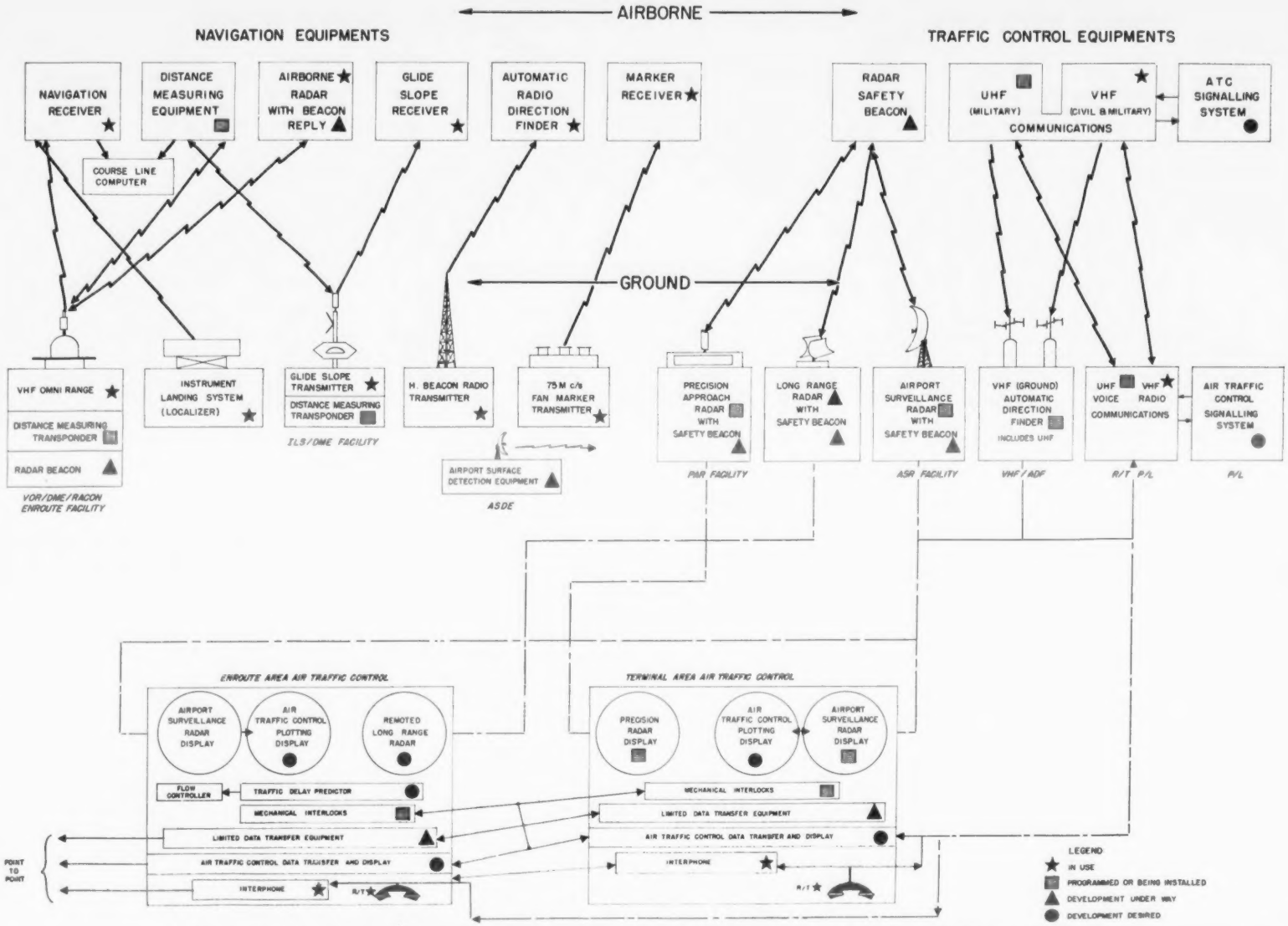
"The Group had to determine, discuss, and evaluate the needs of all users of the airspace. Trips were made into the field by the Group to meet with many different users in order that their problems might be discussed at their very doorsteps. Field trips included, among others, the New York International Airport, air-line operations conferences at LaGuardia Field, en-route traffic control at Washington National and Boston, the All-Weather Flying Division at Wright-Patterson Air Force Base, the C.A.A./Technical Development and Evaluation Center at Indianapolis, and an operational cruise aboard a U.S. aircraft carrier. Special meetings were held with the Air Navigation Development Board, with the Air Defense Command, and with many other interested groups.

"Special conferences were held in the field, which included representatives of such flying interests as the Flying Farmers organizations, Corporation Aircraft Owners Association, the Civil Air Patrol, fixed-base operators, private and itinerant fliers, U.S. commercial air lines, the Airport Operators Council, and the Air Line Pilots Association. The last three were, of course, represented on the full-time Policy Group.

"During most of 1950 the Operational Policy Group diligently carried on with its work. It had been originally estimated that the task would consume about 6 months' time, but the Policy Group spent 10 months of arduous work before producing its outstanding report entitled 'Air Traffic Control and the National Security.'

"The report contains a detailed and comprehensive description of a practical and up-to-date air-traffic-control system for the United States—a system that is flexible and capable of expansion to at least double our present capacity, a system that will permit operations under virtually all-weather conditions, and a system that is based primarily on *electronic equipment*.

"Before closing, I will tell you of the highlights of the Operational Policy Group's proposed system. However, I will make this brief, inasmuch as I note that your afternoon session is to be devoted to a Symposium, the subject of which will be All-Weather Flying. I am pleased to note further that virtually the entire Symposium Panel is made up of such people as Col. 'Al' Key, U.S.A.F.; Bert Moore, Chief of the Enroute Air Traffic Control Branch, C.A.A.; and Sam Saint, Direc-



A chart illustrating the equipment implementation program set forth in *Air Traffic Control and the National Security*, by the Air Coordinating Committee, Air Traffic Control & Navigation Panel, Operational Policy Group (December, 1950).

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tor of the Air Navigation and Traffic Control Division of the Air Transport Association—all of whom were members of the Operational Policy Group. I see that Comdr. A. W. Wuerker, U.S.C.G., Chairman of the Operational Policy Group is also here.

"The Chairman of the Symposium Panel, I notice, is Col. J. Francis Taylor, U.S.A.F., Chief of the All-Weather Flying Division, Wright-Patterson Air Force Base. Colonel Taylor has worked most diligently with the Operational Policy Group during the development of its report and has cooperated extensively—even to the point of making possible a complete Operational Demonstration of the Terminal Area and Enroute Systems as described in the Report. This Demonstration, staged under actual operating conditions, utilized C.A.A. air-traffic controllers and aircraft of all types from jet fighters and huge transports of all elements of Government and industry to the single-engined private plane.

"In view of the Symposium, you will be able to find out, in as much detail as you desire, all about the new proposed system of air-traffic control as developed by the Policy Group.

"I believe it is most important to point out that the proposed system is built on established and existing civil and military programs and, further, that the overall plan lends itself to immediate implementation. In fact, as Chairman of the Air Coordinating Committee, I am pleased to report to you that the Technical Division of the Air Coordinating Committee has already accepted this report and that implementation is already under way. You may be interested to know that, in accordance with the recommendations of the Policy Group, the C.A.A. has under way a stage-by-stage activation of facilities to permit terminal area radar control in the Washington, D.C., terminal area.

"You will note that I have just stated that the first implementing activity was with regard to a terminal area. The Policy Group, in its examination of the deficiencies of the entire system, found that traffic congestion in the large metropolitan terminal areas was the principal bottleneck to the efficient movement of aircraft. This congestion is the prime cause of delays, cancellations, and disarrangement of traffic throughout the entire system. The terminal area situation is particularly serious during the high percentage of borderline weather when some traffic is flying on visual flight rules while other traffic is flying on instrument flight rules.

"Attention has been called to the elimination of these bottlenecks in the major metropolitan areas, because these areas, in turn, lower the efficiency of the operation throughout the *entire United States*. The major portion of commercial air traffic in the United States moves either *to, from,* or *between* some 17 principal terminal areas. *Delays and cancellations spread from these areas to hundreds of other airports throughout the country.*

"The Policy Group makes three major policy recommendations with regard to the terminal area problem. They are:

"(1) *Radar should become the primary traffic control facility in congested terminal areas.* All procedures, traffic patterns, control displays should be designed to supplement the radar and to serve the radar controller. Normally, aircraft would be required to have two-way communications, omnirange, and marker beacon receivers to facilitate radar control and as a safety measure.

"(2) *More air-ground voice communications must be provided.*

"(3) In areas of critical density where the system is fully implemented, it is recommended *that the radar approach and departure procedures should be usable 24 hours a day on the same basis.*

"The Policy Group further reports that another major element in the overall traffic-control system is en-route area traffic control, which is particularly important along airways connecting major terminals. Navigation in such areas will be accomplished by aircraft using established navigation aids, including the omnidirectional ranges and various markers and beacons. Later, the Distance Measuring Equipment will be available. Neither V.O.R. nor D.M.E., as you know, is subject to appreciable weather interference. Improved traffic control in such areas will be accomplished through the use of a new, rapid communications system, supplemented by mechanical interlocks and aircraft plotting and position displays. On particularly congested routes, long-range radar will assist in traffic control.

"Because of its major recommendations with regard to the use of radar, the Policy Group closely scrutinized the limitations of the present-day radar, and the NAV Panel has already requested the Air Navigation Development Board to develop, as a matter of highest priority, a simple radar safety beacon for aircraft control purposes. This transponder is expected to be inexpensive when produced in quantity and ensures radar coverage during such conditions as sleet, snow, and thunderstorms, as well as reinforces the echo from aircraft with poor reflective surfaces—a feature that is particularly important to the operations of jet aircraft and certain smaller private or executive type planes.

"Further, the Policy Group advises that the airborne radar safety beacon provides rapid aircraft identification information, which is of the utmost importance to the air-traffic controller, in addition to extending substantially the range of the radar coverage.

"The Group report points out that the speeding up of terminal area traffic and en-route traffic will result in shifting the bottleneck to a new location—the surface of the airport itself. The Group determined that major airports with maximum capacity of demand will need dual runways, runways of adequate width for instrument operations, approach light systems, adequate turn-off taxi-ways, and probably a minimum of 25 loading gates. This is in addition to the need for an improved system of airport ground traffic control and guidance, which involves among other things the development by the Air Navigation Development Board

(*Continued on page 41*)

A chart illustrating the equipment implementation program set forth in *Air Traffic Control and the National Security*, by the Air Coordinating Committee, Air Traffic Control & Navigation Panel, Operational Policy Group (December, 1956).

(Above) A small selection from the many special-purpose electron tubes developed by Eclipse-Pioneer.

(Center) Sub-miniature "Trionode" tubes, developed by Northrop Aircraft engineers, are capable of performing the job of a conventional vacuum tube ten times their size.

(Right) The research laboratory of Bendix Radio Division has produced this tiny electronic amplifier, weighing less than 2 oz. and capable of magnifying electrical impulses 3,000,000 times.

ELECTRONICS FOR AIRCRAFT

(Continued)

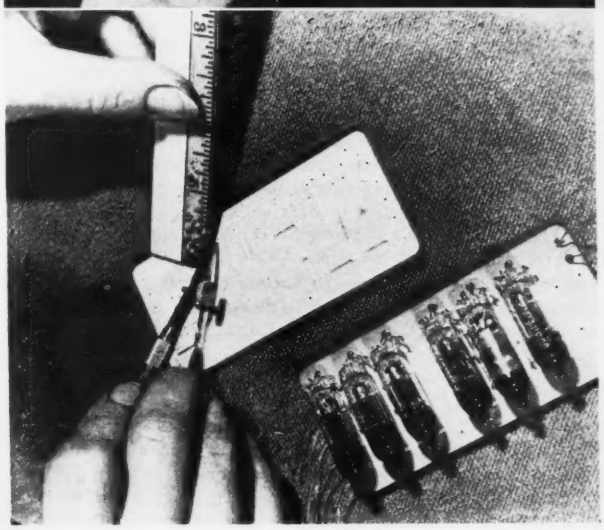
SUB-MINIATURE ELECTRONICS

A guided missile (not to mention a fully equipped modern-day bomber) may contain anywhere from 500 to 1,000 vacuum tubes and several hundred different electronic assemblies. From the standpoint of electronics, it is much more complicated than any large-size radio broadcasting station.

To keep our aircraft from becoming larger than the Empire State Building, it has been necessary to develop electronic equipment smaller than "small." How well the electronics and aeronautical engineers have succeeded in this job is demonstrated by the randomly selected illustrations shown on these pages.

The extreme limits of miniaturization, however, have yet to be reached. The possibilities in this field alone challenge the ingenuity of every electronics engineer and manufacturing company in the country.

(Continued on page 28)



Sub-miniature assemblies, so small and delicate that the wiring circuits can be "drawn" with a special silver ink to carry the tiny electrical currents, are illustrated above. The wire used in the coils of these assemblies is so fine that 20 miles of it weighs only a few ounces and must be handled under magnifying glasses and with special tools, as illustrated below.

Photos Above and Below Courtesy North American Aviation, Inc.

(Below) J. M. Pearce, Chief Electronics Engineer of The Glenn L. Martin Company, inspects some of the intricate and delicate precision assembly details that characterize electronic aircraft equipment.

Problems of Standardizing Electronic Equipment for Aircraft

By

CHARLES R. BANKS*

Aeronautical Radio, Inc.

ABSTRACT

This paper deals with the overall problems of aircraft electronic equipment standards as dictated by a planned common air navigation traffic control system. The problems of implementing aircraft electronics complying with operational and technical system planning are considered, together with a résumé of several active organizations and committees participating in the program. It is hoped that this overall view of the whole program will provide a better understanding of each individual problem of the transition and the ultimate common system of all-weather air traffic control.

Problems of standardizing the aircraft electronic equipment necessary to solve high-speed, high-density aerial traffic require the coordinated effort of operational and technical planning. From the aircraft navigation and traffic problems, the solution of which determines the operational and technical specifications, four chief phases of a complete system arise: (1) formulation of a common system; (2) technical development of a system; (3) design and manufacture of the air and ground equipment; and (4) equipment installation on the ground and in the aircraft.

A system plan wherein technical characteristics are established from the operational requirements provides the guidance for the development of electronic equipment to solve air navigation and air traffic problems. Such operational and technical planning, followed by equipment development, provides the basis for the implementation and the use of each electronic device of the system as it becomes available. The electronic equipment design, production, and installation on the ground and in the aircraft are the steps in transition from present low-frequency four-course range methods of operation to a completely new, highly precise electronic system of navigation and traffic control. It is the many mathematical problems to be solved by electronic means to meet the operational requirements of pin-pointed positions, known rate of aircraft closure with its destination, and computed courses and computed landing schedules that create the requirements for a vast number of electronic functions.

In order to implement the new electronic system, we must proceed from the newly formulated all-weather air traffic, air navigation operational and technical standards to the technical developments, to the design, to the manufacture, and finally to the utilization of equipment. Through all these technical phases of implementing a system, we must utilize known good engineering practices and standards of established aircraft equipment form factors, standards of primary power, and standards of equipment electrical characteristics to expedite the program and to permit the application of our maximum effort to solving the new technical problems of the common electronic plan of air traffic control.

In our scientific approach to engineering fundamentals, we have progressed from the eighteenth-century period of disagreement among the early scientific investigators to the proof and acceptance of the many controversial fundamentals of fact at the beginning of the nineteenth century. Despite our early disagreements and the slowness of our start, we now find ourselves not only in the electronic age but in the "Age of Aeronautical Electronics."

Recognition of Maxwell's laws occupied one entire quarter of the last century. Now, 50 years later, we plan to implement, in the air and on the ground, within a 10-year period a coherent electronic plan of efficient all-weather aerial navigation and traffic control. This system in the 10-year transition period will use omni courses, distance to station measurement, computed courses to establish highly accurate aircraft position, and automatic aircraft position reporting with visual indicators. It will be necessary to use these primary navigation signals and combined computed data to solve three-dimensional rate problems. In the ultimate plan, it must be possible for the system to project the aircraft position into the future at specific times to control traffic. Also the system must be capable of indicating at least one or more alternate safe courses for a given aircraft, as shown by its own projected course or the projected course of other aircraft in the vicinity.

The electronic methods used in the solution to these operational problems must be adaptable for use by all aircraft, as well as for installation on the ground, so that engineers can plan a technical system and design equipments that may be introduced in a methodical arrangement to permit a full transition from present-day equipment and operating methods to the ultimate common system. The electronic equipment plan must stem from the common aircraft traffic control system that is usuable by all aviation interests, and the plan must proceed in an orderly manner through development, design, manufacture, and installation.

To accomplish in 10 years the ultimate system goal, we, as development and design engineers, must utilize all available technical standards and make exceptions to known practices only when the equipment program can be expedited by new techniques or in the cases where definite improvements in dependability, economy, or operating characteristics are of a very real magnitude.

INTRODUCTION

IN REVIEWING HIS OWN ACCOMPLISHMENTS in the field of science, Sir Isaac Newton once said that he often seemed to himself only like a small boy playing on the seashore, diverting himself now and then in finding a

Presented at the Session on Electronics in Aviation—1, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* Chief Engineer.

smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before him. So it often seems in our application of electronics to solve the problems of aerial navigation. Today, we have an operational plan that is technically compatible, but we are often tempted with the diversion of creating the shinier knob, the more attractive box, while the real problem remains unsolved. This instinct for originality is, indeed, the essence of an engineer, for standardization of design is inherently incompatible with his creative mind.

We are not the first to be confronted with this contest between originality and standardization. Before final agreement on basic scientific fundamentals, there ensued a long period of continuous disagreement among the early scientists. This controversy was due in part to their inquiring distrust of the concept of uniformity and in part to the limitations of the minds of men dealing with pure fundamentals.

Today, we, as engineers, use the basic work of Newton, of Maxwell, and of many other early scientists to solve our engineering problems. Thus, in the design and use of electronic products, we speed our creative work through its engineering stages, production, and application to the operational service by the use of basic scientific laws and engineering standards.

Electronics in the airplane is now approaching one-quarter of its total value. In addition to engine ignition and aircraft electrical systems, radio, radar, electrical pilots, electronic computing, and other electrical devices are now being installed in many new aircraft. Because of this vast requirement for aircraft electronic equipment and because it is necessary to use additional equipment to solve air traffic problems, we must conserve our talents and avoid individual investigations of already solved designs when deviations from standards do not achieve major improvements in equipment performance.

However diverting the details of the problem are, we must apply our ingenuity to the creation of apparatus that will perform complex multiple functions with dependable precision and so implement the electronic program of the common system of air traffic control which has been conceived as the ultimate plan. A study of the design and the in-service performance of the many types of electronic units already in use provides the bases for many standards that may be directly applied to the air navigation problems.

Statement of the Problem

Our problem is to implement by 1960 an all-weather air traffic navigation system common to all users of the airspace. For all-weather operation, radio waves provide the only method of continuously exchanging intelligence between the aircraft and ground and between the ground and the aircraft in flight. Thus, an efficient all-weather traffic control system capable of providing accurate guidance and control information from the ground to the aircraft establishes the requirements for a common electronic program for all users of the airspace. The magnitude of this problem can be judged by comparing the precision system of air traffic control and of air navigation with the old four-course radio-range method of instrument weather operation. These low-frequency facilities, in general use during the years from 1930 to 1950 and now to be replaced by a new common system, will be replaced in 10 years at a cost, for the air-borne equipment, of more than 25 times that of the total cost of low-frequency aircraft equipment used during the past 20-year period.

The assemblage of electronic equipment which will accomplish the operational functions required by all users of the airspace and which will take into account such factors as variable aircraft speed and highly dense aerial traffic requires a several-fold increase in the use of electronic equipment on the ground and in the air.

The engineering solution to the electronic control system must be pursued through development, design, manufacturing, and installation to the maintenance of the equipment required to perform the tasks. After an air-ground technical program capable of being used by all aircraft has been established, 3 years are still required to develop and produce one unit of the air-borne equipment. To install air-borne equipment in commercially operating aircraft requires another 2 years. Thus, a total of 5 years is spent from the equipment planning stage to that of operational use. Since many types of electronic devices are required to complete the ultimate traffic control air navigation system, overall standard electrical characteristics must be adopted and adhered to in order to implement rapidly the first electronic units of the system and to avoid obsoleting these units by introducing later equipments having characteristics differing from the common plan.

Thus it follows that standardization of the electronic program technical characteristics is the bridge from the air traffic control operational plan to the final use of this equipment. This bridge must remain firm. We cannot replan, re-engineer, and redesign complex technical programs during the implementation of the system.

Agencies Formulating the Operational and Technical Characteristics of the Common System

Operational characteristics of a common air traffic navigation system were formulated for all users of the airspace by Special Committee 31 of the Radio Technical Commission for Aeronautics. Upon the request of the President's Air Coordinating Committee, this special committee was established in June, 1947, to conduct a study of Air Traffic Control. The Report prepared by the committee members, chosen for their operational and technical experience, considered the basic principles of Air Traffic Control, together with the equipment and procedures required to implement a transition and an ultimate traffic control system based on the study of air navigation and of air traffic control operational requirements, coordinated with technical systems. The result of this intensive survey was the traffic control

plan now known as the "Common System." As its name denotes, it is designed to meet the common needs of the military services, scheduled air carriers, commercial operators, and private fliers.

The Air Coordinating Committee, which originated the request for the R.T.C.A. air traffic control study, was formed in 1946 by the President for the purpose of examining aviation problems and technical developments affecting more than one participating agency of the U.S. Government. By executive order, this Committee is directed to consult with, examine, and submit views of agency department heads and to make recommendations by interim reports with a specific requirement to prepare a yearly report. This body, usually known as the A.C.C., is comprised of representatives from the State, War, Navy, Air Force, Post Office, and Commerce departments, the Civil Aeronautics Board, and a nonvoting member of the Bureau of the Budget.

Historically, the Radio Technical Commission for Aeronautics, usually referred to as R.T.C.A., was organized in 1933 because of the need for coordinated planning among the civil, military, and private aeronautical users. This assembly of all airspace users was necessary in order that technical studies could be conducted to apply radio techniques to the efficient use of the common airspace and the landing areas and to communications and air traffic control. It is an informal and cooperative organization that appoints special committees to perform specific tasks—for example, SC-12, which establishes test procedures and standards for equipment operating on frequencies below 30 mc., and SC-21, a committee concerned with the standardization of the distance-measuring system. These are but two of many special committees working on aeronautical radio equipment characteristics.

It is in the cooperative R.T.C.A. organization, composed of voluntary membership and working without power to enforce its findings, that all agencies, Government and civil, may consider and agree upon aviation electronic technical standards. This group provides interested civil agencies with an equal voice in a technical coordinating body. The R.T.C.A. Executive Committee, meeting monthly, manages the affairs of, and conforms to the policies of, the main assembly. This Executive Committee is comprised of one representative from the following agencies: State, Treasury, Navy, Air Force, Commerce, Federal Communications Commission, and the Civil Aeronautics Board, and the following civil agencies: Aeronautical Radio, Inc.; Aircraft Owners and Pilots Association; Airline Pilots Association; Air Transport Association of America; Radio Television Manufacturers Association; and the Aircraft Industries Association.

The common all-weather navigation system, a plan requested by A.C.C. and prepared by R.T.C.A., was unanimously endorsed by Government and industry and supported by the President's Air Policy Commission and the Congressional Air Policy Board. The "Common System" was compatible with the Commission's and the Board's findings—that our national economy and our national defense required this standardized approach for a solution to air traffic control problems.

A brief explanation is now given of the Air Navigation Development Board, organized to develop the technical characteristics of the two distinct phases of the "Common System," which in the transition period is expected to be in full operation during the year of 1953 and in the ultimate program by 1963. This board was formed after an exhaustive study of the air navigation problem by the Research and Development Board, which recommended its formation. The Secretaries of Defense and Commerce, concurring in the recommendations of the Research and Development Board, issued a charter in May, 1948, for the creation of the Air Navigation Development Board within the Civil Aeronautics Administration. This Board, frequently called A.N.-D.B. (consisting of four full-time representatives from the Army, Navy, Air Force, and the Civil Aeronautics Administration), has a Director of Development with a technical staff to formulate, integrate, supervise, and prepare a single comprehensive budget for all research and development on the "Common Plan."

Liaison with the A.N.D.B. is maintained by the A.C.C. to assist A.N.D.B. technical planning in matters related to the common system operational requirements. It is the A.C.C. Navigation Panel that monitors the technical development of the common program to ensure that the operational requirements of the System are maintained in all Government agencies. These interpretations of the operational requirements established by the R.T.C.A. Special Committee 31, as reviewed by the Navigation Panel of the Air Coordinating Committee, are transmitted to the Air Navigation Development Board to assist the technical formulation of a unified research and development plan for the electronic systems and equipments necessary to implement the transition and the ultimate common air navigation program.

In these Government operational planning, technical planning, and advisory bodies (such as the Air Coordinating Committee, the Air Navigation Development Board) and in other Government bureaus, civil aviation interests are represented by the Civil Aeronautics Administration (C.A.A.), which is charged by Congress to regulate and to develop aviation. The C.A.A. is the technical and the regulatory Government agency established by Congress to assist and further the growth of civil aviation. Through the Civil Aeronautics Board (C.A.B.) regulatory laws are formulated, and through the C.A.A. these laws are enforced. The C.A.B. and the C.A.A., an aviation agency administered in the Department of Commerce, make and enforce laws within the one agency. This dual personality has been well administered during the last 20 years, as attested by the growth and technical progress made in civil aviation. The ground electronic aids common to all users of the air are installed and operated by the C.A.A.

Agencies Implementing the Technical Standards of the Equipment for the Common Technical System

The technical system of the common plan is guided by the specifications and equipment characteristics established by the Air Navigation Development Board. Individual development projects may be assigned to the technical bureaus of our military services, or they may be guided by the C.A.A., by research organizations associated with our universities, or by the laboratories of our electronic manufacturing industry. The ground aids of this Common System are installed and operated by the C.A.A., while the air-borne units are installed and operated by the users of the airspace. Technical standards for the air-borne equipment are established by the military bureaus, by the C.A.A., by the commercial users of the airspace, and by the Radio Television Manufacturers Association for the itinerant flier. Frequently, common specifications and standards are established for specific equipments among all the airspace users. R.T.C.A. continues to develop, through its common meeting ground, many technical standards for the system to guide the implementation of the transition program for the military, the C.A.A. commercial air lines, itinerant flier, and the radio manufacturer.

In commercial aviation, Aeronautical Radio, a nonprofit commercial aviation company known as ARINC, has, through industry committees, established airborne equipment standards to ensure technical compliance with the operational and the technical characteristics of the ground and air standards agreed upon in R.T.C.A. for the implementation of the A.N.D.B. technical developments. These air-line industry equipment characteristics consider not only the electrical requirements but the installation problems, the dependability factors, and the pilots' use.

Since the end of World War II, air-line technical personnel, identified as the Airlines Electronic Engineering Committee (A.E.E.C.), working with the staff assistance of ARINC, has been formulating standards for aircraft electronic equipment to be used in air-line services. The activity of this committee is concerned with the immediate implementation of the transition electronic equipment and the ultimate equipment necessary to perform the functions outlined in the R.T.C.A. Common Plan. With the staff assistance of ARINC, the A.E.E.C. has prepared V.H.F. navigation communication receiver and glide slope receiver characteristics and a control circuit specification for aircraft radio equipment and has produced the *Aeronautical Radio Synchro System Manual*. Other equipment projects now active in the committee are both H.F. and V.H.F. multichannel communications equipment, as well as the new distance-measuring equipment.

An example of the aircraft transition program technical problem of system implementation can be observed by looking at the problem involved with one unit of the system, the comparatively simple transition from a ten-channel V.H.F. transmitting and receiving equipment to one providing 360 channels for the ultimate Common System of airway dispatch, traffic control, and airport tower communications. In planning equipment to perform these functions by double-channel and by single-channel communications, with provisions for a private line visual display of intelligence, we have one example of the many technical problems. The engineer in designing V.H.F. communication equipment for the transition period must plan for its use in the ultimate program. The present-day air-line ten-channel air-borne V.H.F. communications equipment (modified to provide 20 and, again, to provide 50 voice channels) will become obsolete during the transition period because of insufficient channels and will require the installation of new equipment to provide these additional channels. This new equipment must be designed to expedite its installation into existing aircraft during the transition period and to provide the functions and the channels necessary for the ultimate common air traffic control system.

This ultimate air-borne V.H.F. communications equipment will be capable of operating on 360 discrete channels with a receiver sensitivity of a microvolt, and it is this equipment that will be required to operate in close proximity to 120-channel localizer omnirange navigation and approach control communication receivers. Two such communications units and two navigation receivers will generate a multitude of spurious signals, in single and in multiple combinations, which may interfere with the reception of the desired signals. The probabilities of spurious signal interference become still greater as additional equipments are installed in the aircraft system. It is because of the complexity of the many technical problems that are generated within the electronic system, as in the case of the spurious signals, that we must carefully plan our electronic units and establish standard characteristics.

Installation of the Common System

The problems of implementing the air-borne electronic equipment for the transition and the ultimate Common System of air traffic control can be estimated by comparing the low-frequency four-course radio-range method of air navigation and traffic control with the transition and the ultimate precision navigation method of efficiently controlling dense high-speed air traffic.

The four-course range system required the use of a low-frequency receiver in the aircraft. A medium-frequency transmitter was used with the range receiver for two-way communications with the ground station. As flight operations began to predicate aircraft schedules based upon the pilot's use of this radio apparatus, the second range receiver was installed in the airplane. In this early period, the air lines established a communications network capable of maintaining contact with the aircraft throughout its flight. The basic low-frequency system was improved over a 20-year period by adding

(*Continued on page 55*)

ELECTRONICS FOR AIRCRAFT

(Continued)

PACKAGING ELECTRONICS

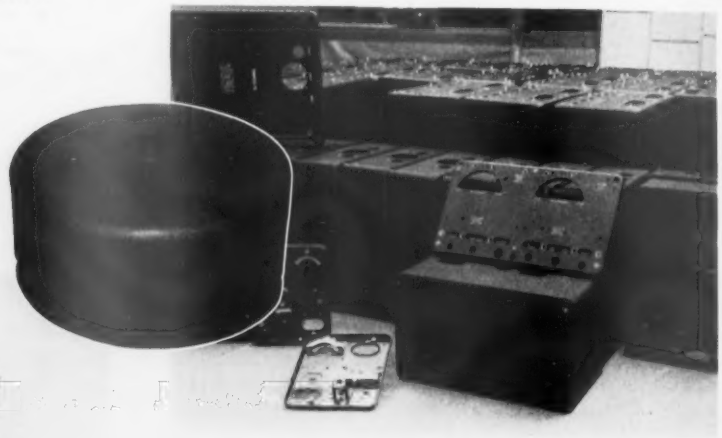
Weight and size are the primary considerations given to any equipment that is to be air-borne. However, with modern-day military aircraft operating through such a wide range of altitudes, temperatures, and speeds, the problem of giving adequate protection—through housing and packaging—also becomes one of prime importance. This is particularly true of delicate and sensitive electronic equipment and instruments, which must function perfectly regardless of external conditions.

To meet the present specifications requested by the Air Force and the Navy, electronic equipment must be capable of operating efficiently at 70,000-ft. altitudes, through temperatures ranging from −60° to +200°C.; stand a shock of 50 G's for 10 millisec., and have a minimum life of 1,000 hours.

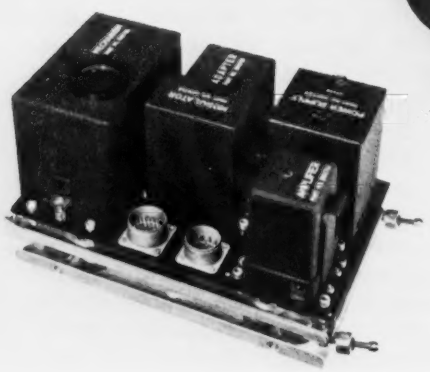
(Continued on page 31)

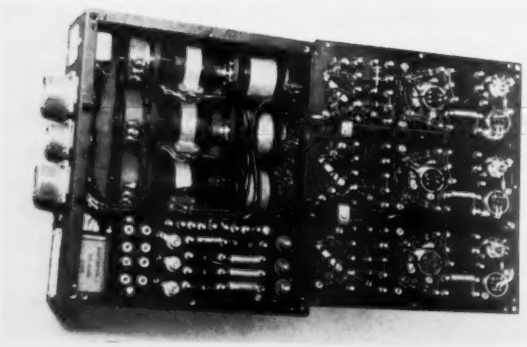
(Above) Assembling and "packaging" of delicate electronic equipment are important parts of the aircraft manufacturer's job these days. This is a scene in The Glenn L. Martin Company plant.

Magnesium, because of its light weight, is extensively used for casings and special housings for electronic equipment. The computer cases *(right)* and special pressurized housing *(center)* are produced by Brooks & Perkins, Inc., of Detroit. The functional packaging of air-borne electronic equipment designed and manufactured by Servomechanisms Inc. is illustrated below.



(Bottom left) This Integrator unit of an Angular Rate and Displacement Indicator, produced by Doelcam Corporation, is a typical example of compact, functional packaging.





Sub-miniature assemblies, such as the one held here by Eleanor Hatch, of North American Aviation, are conveniently packaged and hermetically sealed in plastic cases.

Packaging of Air-Borne Electronic Equipment

ORVILLE M. DUNNING*

Hazeltine Electronics Corporation

THE PROBLEMS ENCOUNTERED in packaging electronic equipment today are largely the result of the drive for miniaturization which began near the end of the war and has been building up since that time. Just prior to World War II, the trend for packaging air-borne electronic equipment had tended to stabilize for a variety of different purposes, around the familiar ATR construction. This had the advantage of providing a series of standard package sizes which could be conveniently stacked, standardized connection arrangements, panel locations, and other similar conveniences. It also involved the almost universal use of a horizontal chassis pan with vacuum tubes and major components accessible from the top and all wiring and minor components on the bottom. Over the years, this has proved convenient to manufacture, cheap, easy to service and maintain, and therefore completely satisfactory. It has been tested in the hard school of actual manufacture and use and has succeeded. Most of the equipment that was built in this form was no more complicated than a total of ten or 15 vacuum tubes with the corresponding circuit elements.

As a result of the enormous growth of electronic aids during and since the war, these arrangements have become somewhat obsolete. To begin with, the total amount of electronic equipment to be carried in aircraft has multiplied with the expansion of electronic functions, and the end has not been reached. There are, today, dozens of proposals to increase the number of functions to be performed by additional electronic equipment. Not only has the amount of equipment multiplied but, in addition, the complexity of each individual equipment has grown several fold. Equipments with a total of 50 to 100 tubes each and with greater mechanical complexity are frequently suggested. Thus, the total quantity of electronic equipment has been increasing on a sort of square law curve and threatens to continue to do so until a limiting action of some kind appears. It is evident that, if an attempt is made to provide this multiplication of facilities on the basis of the old conventional ATR construction, too much of even the largest aircraft would be devoted to electronic equipment.

Designers have, of course, been continuously conscious of the growing problem and have done a number of things to alleviate the situation. The first of these was the use of miniature tubes which permitted a gain of something approximating 2 to 1 in volume but with no fundamental change in form or design practices. This has been followed by the subminiaturization trend involving not only tubes but all components. This may be said to have as its eventual objective the accommodation of both the increased number of equipments and the increased unit complexity within the space and weight allocated to the far simpler gear of some years ago.

As of now, subminiaturization can no longer be considered a new art. It has been worked on for at least 5 years and has been written about extensively in the engineering literature. Many and varying ingenious techniques and components have been proposed for accomplishing the purpose. The very fact that after all this work and time there is no standardized or accepted subminiature packaging technique, or even any identifiable trend in that direction, is proof of the difficulties inherent in the problem. It must be kept in mind that any new and different technique of this sort, involving a wide departure from a previously standardized technique, can only be evaluated and shaken down through the orderly process of actual manufacture and use. No amount of advance speculation can completely eliminate the trial by fire. Past experience indicates that eventually one or two techniques will emerge as most generally satisfactory and will be almost universally adopted.

Most of the problems encountered in arriving at a subminiaturized equipment design can be summed up in the following:

(1) The development of new small-size components. Reduction in size is usually accompanied by

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deterioration of characteristics or performance. What is required here is frequently a reduction in size with improved performance at least in some directions. With the already highly developed state of the electronic art, it is obvious that such an objective cannot be achieved without great effort and much time.

(2) Solution of the problem of increased temperatures inherent in a great decrease in volume for a given function. This phase of the problem has already been much discussed. The two basic solutions that have been proposed are (a) the use of components that will operate at much higher than conventional temperatures without deterioration or (b) means for sufficiently accelerating the conduction of heat away from the equipment to avoid elevated temperatures. The choice between these alternatives is by no means clear. A compromise may emerge.

(3) Interconnection and mechanical support of components. Our conventional fastenings, such as screws and rivets, are frequently too space-consuming and lack adequate strength when reduced in size. Conventional methods of wiring become too cumbersome, but a reduction in size of terminals and wire results in a loss of sturdiness which cannot be tolerated.

We still seem to be a long way from achieving a satisfactory answer to these problems.

It is not the objective of this paper to make further new proposals for techniques in subminiaturization or even to attempt to appraise those already made but rather to call attention to one or two criteria for sound designs which appear thus far to have had too little attention.

The process of consolidating a large number of circuit elements in a small space invariably means that the total volume must be rather completely filled. This, in turn, inevitably reduces the accessibility of individual components. A brief comparison between an old style chassis pan equipment and almost any modern subminiaturized design will emphasize the truth of these statements. The problem of supporting rigidly and, at the same time, maintaining adequate insulation renders accessibility most difficult in any case. Some designers, in approaching the subminiature packaging problem, have attempted to provide access by means of quickly removable multiple subassemblies. Other designers have apparently concluded that such access is not important or, in fact, may be disadvantageous. It has been argued that the time required to locate and correct a fault may, in many instances, be much more than the actual value of the individual subassembly involved. If this is true, the servicing problem could be greatly simplified by simply locating and then removing and replacing the defective subassembly with a new subassembly. These arguments have led several designers to propose subminiature constructions in which accessibility and serviceability of individual components have been almost, if not entirely, eliminated.

If the argument for throwing away the subassembly instead of trying to repair it is sound, the job should be done by procedure instead of being designed into the equipment. In other words, the service personnel should be instructed to discard such subassemblies without attempting detailed analysis of the fault rather than being required to do so by the inherent design. Anyone who has had contacts with the field will recognize that there are times when a stock of suitable replacements is not available. Under these circumstances, a resourceful repair man can frequently get equipment back into working condition with no more than a soldering iron and a little ingenuity, provided the individual components are accessible. A design that deprives him of this possibility seems to be unsound.

A much more important objection to the philosophy of nonaccessibility is to be found in the production process in which these units are originally constructed. If a relatively large quantity of units is to be produced rapidly and on an economical basis, the design must be considered from a production point of view. Such a production process itself is a highly orderly procedure if it is at all efficient. Ideally, 100 per cent perfect components should arrive at the production line just in advance of their requirement in the assembly procedure. An attempt to approximate this condition is made by providing a lead time for components and an inspection procedure that will weed out at least most of the defective components in advance of their utilization in the line. If care and skill are used in this process, orderly production can and does result.

It is, however, the experience of every manufacturer that unexpected troubles develop all too often during production. These occur for a variety of reasons, such as a sudden change in some unspecified characteristic of the component, a change in manufacturing methods in components, etc. In the usual orderly production setup, provision is made to handle such difficulties by including repair facilities. This, however, demands accessibility to permit such repair work to be done rapidly and conveniently. Therefore, any design that is not completely accessible as to components will be unsatisfactory in production.

If the design is such that when one component of a subassembly fails the entire subassembly must be thrown away, a still greater handicap to the production process results, since it makes it almost impossible to determine with any precision the exact quantities of material required. Many good and useful components are thrown away with the defective one. Delivery schedules for components, production schedules for subassemblies, and all other related activities are thus rendered indeterminate. Such situations are abhorent in the order of the production process.

Designs that involve complete inaccessibility of the components have actually been tried a few times—not just recently but over 25 years or more. In every instance the production experience with such designs has been so unsatisfactory that they have been promptly abandoned in favor of more accessible designs.

(*Continued on page 41*)

ELECTRONICS FOR AIRCRAFT

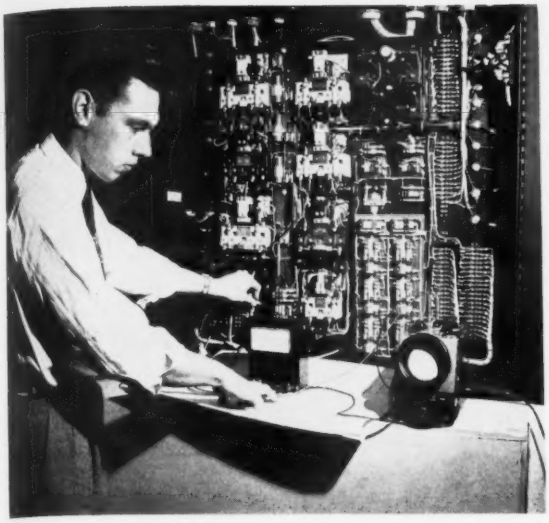
(Continued)

COMPUTERS AND ANALYZERS

The speeds with which supersonic aircraft and missiles travel today have introduced problems in mathematics that defy solution by human beings within time limits that are practical.

Once again, electronics has been called upon to bridge the gap. From the small, portable, "trouble-shooting" engine analyzer (*pictured below*) to the multimillion-dollar electronic computers housed in some of our universities and research laboratories, these "magic brains" save untold hours of human labor.

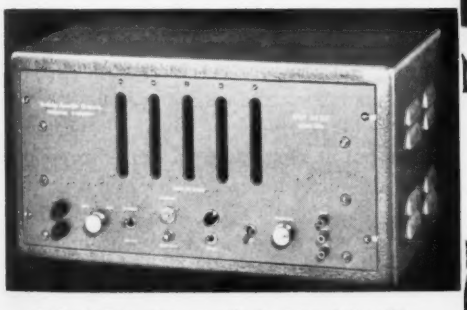
(Continued on page 37)



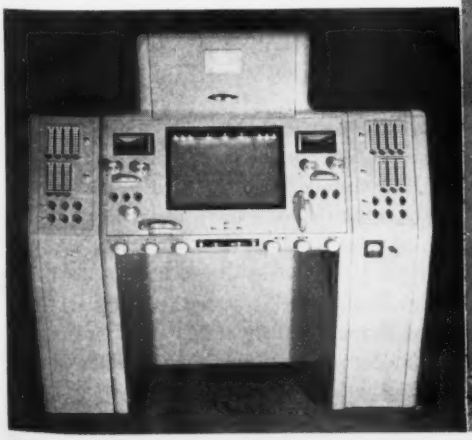
The complexity of an "electronic brain" may be judged by this photo of the power supply junction box of Boeing Airplane Company's analog computer.

(Right) **An electronic portable engine analyzer, developed by Sperry Gyroscope Company, detects and interprets engine troubles more rapidly than would be possible for a human mechanic.**

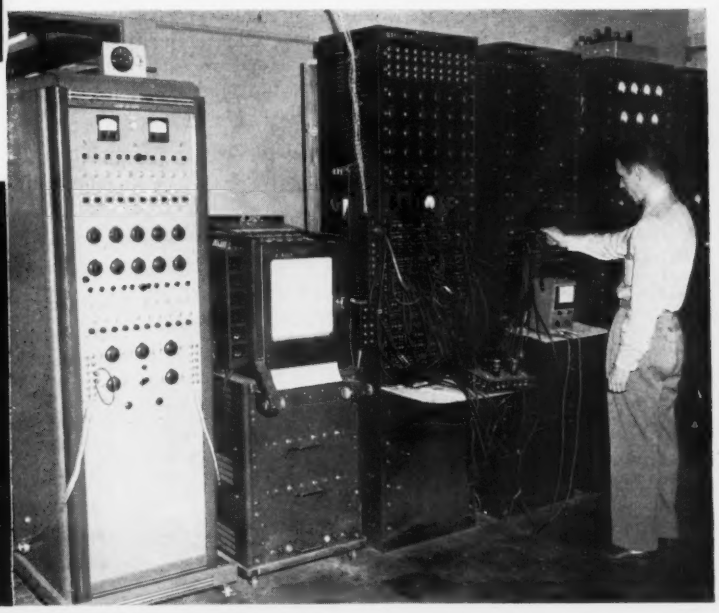
(Below) **Typical of different types of electronic calculators is this "Events-Per-Unit-Time" Meter developed by Berkeley Scientific Corporation.**



(Below) **This device, called a Theodolite Film Reader by Telecomputing Corporation, records (in IBM card form) data originating on 35-mm. film records of missile flight paths.**



Bell Aircraft Corporation—with its guided missile, rocket engine, and subsonic aircraft research and development program—has found great use for electronic analog computers of the type shown below, where differential equations of the seventh order can be computed at a great saving in man-hours.



Air-Borne Antenna Problems

By

DR. HARALD SCHUTZ*

The Glenn L. Martin Company

SYNOPSIS

A few years ago the design of antennas for aircraft was a simple matter. Wires could be strung between wing and tail surfaces or loops mounted outside the fuselage. Aircraft were slow, and antenna drag was of little importance.

Modern high-speed aircraft, piloted and pilotless, carry many types of electronic gear. Antennas covering a wide range of frequencies and capable of filling a variety of radiation requirements must be supplied. They must operate under different environmental conditions and must be able to radiate considerable power.

At the same time, aircraft have been streamlined to aerodynamic perfection, and antennas may no longer protrude into the air stream. Stress analysis has progressed, and weight economy has forced utilization of the skin of wings and fuselage to carry load forces. Therefore, it becomes increasingly difficult to obtain permission to cut the skin. Wing thickness is reduced, and inside space is utilized for structural members, controls, fuel storage, and armament. Space for antennas is hard to find.

A compromise between justified requirements of air-borne antennas and of aircraft to carry them aloft must be achieved. For this purpose, areas of mutual understanding between aircraft and antenna engineers must be created and cultivated in the common interest of producing a well-balanced design.

Air-borne antenna design makes use of practically all known antenna types. Complicated mechanical scanning mechanisms, dipole and slot antennas, helical antennas, polyrods and arrays of radiating elements, lens structures, electromagnetic horns, and many other types are being continually improved and adapted to air-borne use.

DISCUSSION

A RADIO ENGINEER WHO DESIGNS electronic equipment feels at home among his friends. His equipments accept electrical inputs. They do something with those inputs and produce electrical outputs. The radio engineer stays within the house, he has his family all around him, and he's quite happy. No enemy threatens him unless it is somebody who wants to standardize his setups or somebody who wants to force him to subminiaturize his equipment, which are admittedly difficult problems. The antenna engineer, however, is beset by the hostile world. His problem is to design a good antenna that works satisfactorily in a whole system of equipment. I want to stress the system standpoint because it is extremely important. Antenna engineers can design satisfactory antennas if the specifications of performance are given, and many different antennas can be mounted on various types of aircraft, but overall results are often disappointing.

Just recently, an aircraft engineer took a trip out West to a Government testing facility. He came back with flashing eyes, called me to his office, and said: "We have the most inefficient antenna group I have ever seen. You spend a great number of dollars, precious man-hours; you disturb the aerodynamicists, you bother the stress engineers; and what do you get? Those awkward, large, drag-producing heavy structures. Now, when I was out at such and such a proving ground, I saw the nicest, smallest antenna; it was nothing but a button 1 cm. high. That's what we want on our airplanes and I wish you would see that we get it." I asked the man what exactly this antenna was supposed to do. He didn't know, of course, because he is not a radio engineer. I asked to see the antenna pattern, which he couldn't get because it was a classified project. Then I explained to him that an antenna by itself may be wonderful, and yet it may not work on the airplane. I also admitted that we were probably not smart enough for the problem, and I expressed my desire to see the masterpiece. I may get to see it in the future.

Let us now discuss what antennas really are. Antennas are transducers between a transmission line and outside space. Therefore, in an electrical sense, they are not much different from other transducers. Unfortunately, if we want to apply those antennas to an airplane, we have to reckon with system requirements.

Looking at antennas, we discover that they may take many different shapes. In fact, in our laboratory we have a small museum where we have devices looking like cuspidors, others looking like rolling pins, others looking like optical slots, and others are pieces of wire.

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* Head, RF Engineering Section.

There are many other different things—megaphones and what have you—and all of them we call antennas to the amazement of people who do not directly work with them.

Energy is usually transmitted along wires in electrical equipment, and, in recent years, where the frequencies get higher and the wave lengths get shorter, energy is also transmitted through coaxial lines or through pipes. An open-wire line transmits some of the energy and it radiates some. Therefore, every open-wire line also is an antenna. It is our problem to build good antennas—that is, antennas that radiate out as much as possible of the energy impressed upon them, or, conversely, that receive almost all of the energy they can glean out of space.

Please refer to Fig. 1. It explains some of the frequency-band denominations. You see the Very Low Frequency Band below 30 kc.; then the Low Frequency Range, the Medium, the High, and the Very High; then they find that radio engineers ran out of adjectives, so they called them Ultra High, Super High, and Extremely High Frequencies.

Since the decimal system has no end, it is possible to have a few more decades, and then you get into heat radiation and visible radiation and into ultraviolet. This points up the fact that all the radio waves and all the other electromagnetic radiations are cousins. A magnetic and an electric field, vertical to each other, have to exist together. If you get rid of the magnetic field in such radiation, you also get rid of the electrical, and the other way around. As the frequency goes up, the wave length goes down, which should be remembered.

For systems considerations, we are also forced to consider the characteristics of radio-wave propagation through space. If you just have space and nothing else in it, there isn't too much difference in wave lengths of propagation. Most wave lengths will work satisfactorily. However, space has been filled for us by nature with all sorts of things. There is water vapor, there is the interesting ionosphere, there are also things projecting out of the ground and many metallic objects projecting out of aircraft. Therefore, propagation characteristics must be carefully considered. In general, we will find that some wave lengths or frequencies are adaptable to some conditions but not to all of them.

Before we can even begin to design an antenna, we must consider that the antenna must work satisfactorily under environmental conditions. If we now consider antenna parameters, we immediately encounter the term of "antenna gain." Everybody wishes to have a high-gain antenna. Antenna gain works equally well in transmission as it does in reception—that is, if the antenna is a transmitting antenna of high gain, it works the same way in reception—that is a law of reciprocity which proves useful for measurements.

Antenna gain is often referred to an ideal gain standard known as the "isotropic radiator." Such a radiator is supposed to radiate equal energy in all directions through 360° of space. Such an isotropic radiator, while continually referred to, is extremely hard to build; in fact, I have never seen one built.

The first restriction is a hemispheric radiator—that is, a radiator radiating equally well in all directions in one hemisphere. That, for some navigational applications, is an extremely desirable air-borne antenna. Even this is hard to build, and I want to say it is difficult to approach anything like an omnidirectional radiator on an airplane. On the other side of the picture, we find sharply directive antennas, and these again become harder and harder to build as we increase the directivity.

It is, for instance, quite feasible to build an antenna system that will concentrate almost all of the radiated energy inside an angle of less than 1°, which is a sharp bundle of energy indeed. However, I have never seen an antenna that will produce completely parallel rays. Sometimes, however, I find people proposing that we build a lens antenna to produce convergent rays. In long-range work one could realize extremely high gains with it. Maybe one could build a good radar that way.

Another term found in radio engineering is the "polarization" of the electromagnetic field. The plane of the electric vector is usually assumed to determine the polarization. If its plane is vertical, the wave is said to be vertically polarized; if horizontal, it is a horizontally polarized wave; or, finally, we may assume that this vector rotates. Its speed of rotation depends on the frequency, and, if the vector always stays the same magnitude, we speak of circularly polarized waves. However, these, again, are hard to achieve, and we frequently wind up with elliptically polarized waves rather than circularly polarized ones.

Then we get a specification calling for a certain maximum ellipticity. To compute the power gain of our antenna types, we introduce a useful term called "the antenna aperture." The antenna aperture is the size of its opening. The antenna may be a horn, it may be a reflector, it may be a lens, it may be a slot, it may even be a wire, but it is always possible to compute or to experi-

VLF	< 30 KC	MYRIAMETRIC
LF	30 -300 KC	KILOMETRIC
MF	.3 -3 MC	HECTOMETRIC
HF	3 -30 MC	DECAMETRIC
VHF	30-300 MC	METRIC
UHF	300-3000 MC	DECIMETRIC
SHF	3 - 30 KMC	CENTIMETRIC
EHF	30-300 KMC	MILLIMETRIC

FIG. 1.

ISOTROPIC	1
HALF WAVE DIPOLE	1.64
OPTIMUM HORN	$10\ A/\lambda^2$
REFLECTOR OR LENS	$\sim 7A/\lambda^2$
BROADSIDE ARRAY	$4\pi\ A/\lambda^2_{max.}$

FIG. 2. Antenna power gain.

ment and find the antenna aperture. This aperture is expressed in numbers of wave lengths rather than inches or centimeters.

In referring to Fig. 2, we find some rough figures, and later it will be shown why they *are* so rough. Various types of radiators are shown. On the top, you see the isotropic radiator, and, since it is our gain standard, we assign gain 1 to it. Then we have the half-wave dipole, which has become familiar all over the land because of the innumerable television antennas we see sprouting from roofs. It has a gain of 1.64. We then see the optimum horn, a megaphone-like structure, the flare of which has been developed in such a way that the best possible gain is obtained. A indicates the aperture; λ, the wave length. You see how aperture, wave length, and gain are related. The next line shows a reflector or lens antenna. Please note the approximate sign. The gain is about $7A/\lambda$. The uncertainty comes about because of the way we illuminate the reflector or lens. The illumination determines the gain and other characteristics.

The last line shows the broadside array. A broadside array is an array or a group of individual radiators supplied from one or several sources of energy in a carefully regulated manner to produce a beam vertical to the axis of the array.

A question may be in order to find out why one uses very high, ultra high, extremely high, etc., frequencies. Fig. 2 gives the answer. If one wants a high antenna gain with a sharp beam, he must have an antenna measuring many wave lengths. Since few people will happily permit large air-borne antennas, one must use a short wave length. Limitations of propagation through space must be remembered.

Radars in the last war invaded the so-called microwave region, which might be thought to extend from 1,000 mc. up. In trying to understand the operation of microwave antennas, we are helped by concepts of optics. We speak about plane or flat wave fronts. Plane wave fronts might be produced by a point source, radiating isotropically, located infinitely far away.

On Fig. 3 we see a plane wave arriving from the left side. The point source is assumed to be infinitely far away. The wave impinges upon a slit. This slit is the antenna aperture. Following a theory first advanced by Huygens, the radiating aperture is thought to comprise a large number of elementary sources. All of them will radiate equally in all directions. However, the ones that are in the middle of the aperture will be greatly impeded by their neighbors. It is only the ones at the edges of the slot at A and B that will be fairly free to radiate in all directions. Thus, a beam will be formed.

Now, we have the possibility of having waves radiate out straight, but waves can also travel out at a slant. It is easy to see that, if the angle of slant, the distance from the slot to the reference plane, and the wave length are in appropriate relation, there will be points on the reference plane on the right side at which the individual waves reinforce each other and other points at which destructive interference is observed.

Therefore, a radiating slot will produce a pattern with one peak of intensity and pronounced nulls on each side, then a smaller peak, then another null, and an even smaller peak, etc. The curves are familiar to students of optics.

We get a main lobe of energy and side lobes. Side lobes in air-borne-antenna application are usually disturbing. In a radar antenna with strong side lobes, for instance, one might pick up a target in one of those side lobes and think it is straight ahead when the radar antenna points straight ahead; yet, the target in the side lobe may be 50° off. This might cause navigational action that is unjustified. One might fly right into the target he wishes to avoid. Therefore, side lobes are bad in most antennas. There are methods to reduce side lobes.

Let us assume that we have a paraboloid reflecting antenna that is supplied from a small horn, as is the case in many radars. The horn feed illuminates the paraboloid dish just as an incandescent filament illuminates the mirror of a searchlight. In Fig. 4 will be seen in the first column the taper of the illumination at the edge of the dish. The illumination at the edge of the reflector is reduced or tapered. We project most of the energy to the center of the antenna reflector and less and less to the outside portions. If the illumination is, for instance, 10 db. down at the edge, then the side lobes will be 22 db. below the peak of radiation, while with constant illumination the side lobes are only 13 db. down. If we would taper our illumination to 20 db. down or to 1/100 of the power at the center of the reflector, we would

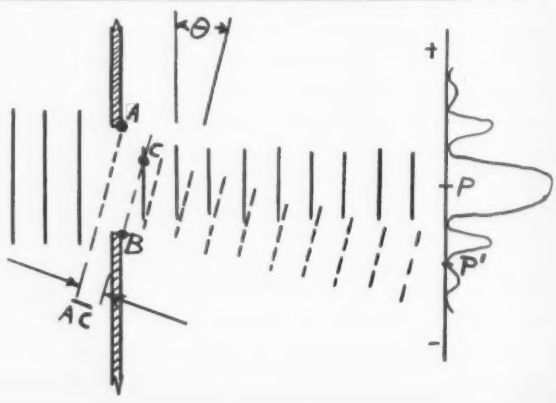


FIG. 3

ILLUMINATION AT DISH EDGE	GAIN	E PLANE WIDTH	H PLANE WIDTH	SIDE LOBES
CONSTANT	$\frac{4\pi A}{\lambda}$	$\frac{51\lambda}{a}$	$\frac{51\lambda}{a}$	-13 DB
-10 DB	$\frac{2.4\pi A}{\lambda}$	$\frac{57\lambda}{a}$	$\frac{57\lambda}{a}$	-22DB
-13 DB	$\frac{2.2\pi A}{\lambda}$	$\frac{70\lambda}{a}$	$\frac{72\lambda}{a}$	-28DB
-16 DB	$\frac{2\pi A}{\lambda}$	$\frac{79\lambda}{a}$	$\frac{79\lambda}{a}$	-33DB
-20 DB	$\frac{1.8\pi A}{\lambda}$	$\frac{90\lambda}{a}$	$\frac{90\lambda}{a}$	-40DB

A = REFLECTOR AREA

a = APERTURE

FIG. 4.

get side lobes 40 db. down or 1/10,000 of the energy of that in the main lobe.

Tapering the illumination also disturbs antenna gain and beam width. We find that if we taper the illumination—that is, if we supply less and less energy to the outer edges of our lens or reflector or to the outer elements of our antenna array—we might almost have eliminated these parts.

Inefficient use is thus made of the antenna aperture. Therefore, we find that for a certain antenna gain we have to build the antenna larger and larger to obtain lower side lobes. Thus, it may be said that one can get a certain antenna gain, a certain side-lobe level, and a certain beam width; that all of those are tied together by natural laws; and that these cannot easily be altered by decree, although people sometimes attempt to do just that. However, in years past it was difficult, I understand, to legislate π to a round number.

Some of the more frequently used antenna types are dipoles, slot radiators, horns, reflectors, refractors or lenses, just straight drag wires, or wires hanging on the outside of the plane. There are also arrays of radiating elements, elements of which can be almost any of the types I have mentioned. The antenna designer, therefore, has many degrees of freedom, and he needs considerable judgment, ingenuity, and imagination to cope with his problems.

So far, we have examined antennas in general. Let us now discuss antennas near conducting structures. When mounting an antenna on some metallic structure, one finds that, although the antenna by itself (measured under good laboratory conditions) has a fine radiation pattern, it may show inferior performance. Fig. 5 shows a radiation pattern. It is a polar diagram. The radius vector from the center out in any direction may indicate either the voltage or the power radiated in that direction. Antenna patterns have many different shapes. The pattern shown in this figure has a strong lobe forward, some rather pronounced side lobes, and noticeable back radiation. We often refer to the antenna beam width as the half-power beam width. The half-power beam width indicates how many degrees lie between directions in which the antenna radiates one-half of the maximum power. Sometimes we refer to the 1/10-power beam width. The half-power beam width is applied most frequently.

Discussing antennas near conducting structures, we find that the conducting structures strongly influence performance and become part of the antenna. If you have a beautiful horn antenna mounted on a metallic airplane structure, you will find with dismay that much of the airplane gets in on the act and starts radiating. If you are in a position to measure the radiation pattern of airplane plus antenna, you are to expect disappointments. In addition to taking part in radiating, the aircraft will be shadowing the antenna. In case one wishes to mount an antenna (a stub, for instance) on the top of an aircraft because there is some room available and because nobody objects particularly, he will discover that fairly little of the power may go below the aircraft.

It is helpful to think of a light source mounted in place of the antenna. If the light source were shaded, maybe the antenna will be shaded too. Currents can certainly be induced in the metallic structure of the aircraft, not only in the antenna.

When people have selected aircraft and antenna performance specifications, they frequently expect a finished design from the antenna engineer in a short time. They are likely to be disappointed because it is a difficult job to match antenna and aircraft.

Antennas are used on a wide variety of aircraft. Aircraft may be piloted or pilotless and may be fast aircraft or slow, and the antenna problems vary accordingly. As aircraft get speedier, it becomes more difficult to obtain permission to have anything protrude in the air stream. Aerodynamicists have a hard time as it is to

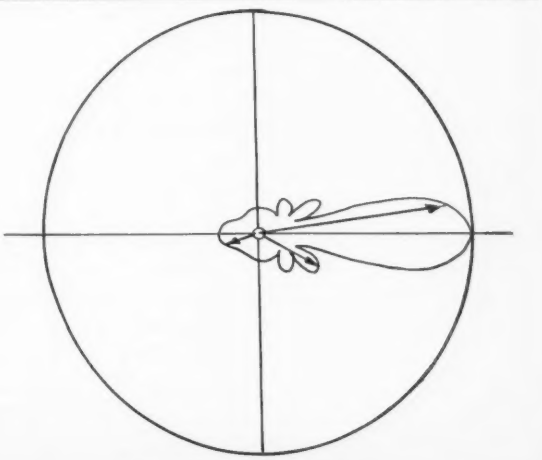


FIG. 5. A radiation pattern.

keep the airflow smooth around the aircraft; if we inject spikes, wires, bottles, or other such things in the air stream, we find that we lose much speed or that we have to install larger engines. Therefore, there is a premium on low-drag or zero-drag antennas that are flush-mounted. These flush-mounted antennas get us into difficulty, and I should like to give you an imaginary example of how we would proceed in the design of a very-high-speed aircraft antenna.

Let me first explain how we should not do it. Somebody has designed an airplane. They wish the airplane to be fast and light, to have a long range, to be heavily armed if it is military, or to carry many passengers if it is commercial. All those parameters are familiar to those in charge of the project. In any aircraft company, the men in charge of the project know about aerodynamics, structures, and propulsion. They even know about the generators and transformers or storage batteries, and they may have a fair idea of communication equipment that must be accommodated. Odds are that they have little experience with antennas. Therefore, they will go ahead and develop a preliminary design to a fairly complete stage, until the thinking has, so to speak, frozen over. They have a plane in mind. Then suddenly they remember that there are a lot of antennas to be used. The company I work for now has designed for the Air Force a speedy experimental bomber, and it carries a number of antennas. However, in this case, the process I am just outlining was fortunately not followed. Therefore, we have at least tolerable antenna installations; few are even better than tolerable, for good reasons. Well, in our imaginary poor way of proceeding, the project engineer, well along toward having his plane on the boards and already beginning to tool up for manufacture comes to the antenna man and says: "Here is the plane. You know what radio equipment we need. Will you please put in the antennas?" We approach the problem; we look at the frequencies; we are told what coverage of radiation we need for beacons, for communication receivers, for radio compasses, for search radars, for homing equipment, for DME equipment. I could mention many more. Then we say: "Well, an antenna to fill this one should stick straight out of the tail surface 2 ft.; this other antenna necessitates a bubble at the belly of the plane right in the deepest point. It should have a 3-ft. diameter, and a radome or covering should be 2 ft. out of the belly of the airplane." Therefore, we proceed happily and we meet difficulties. We are told that our antennas may not stick into the air stream—period. The plane was not designed for additional drag, and, mind you, I am not trying to be funny. That is a reasonable statement. The additional drag does cause difficulty!

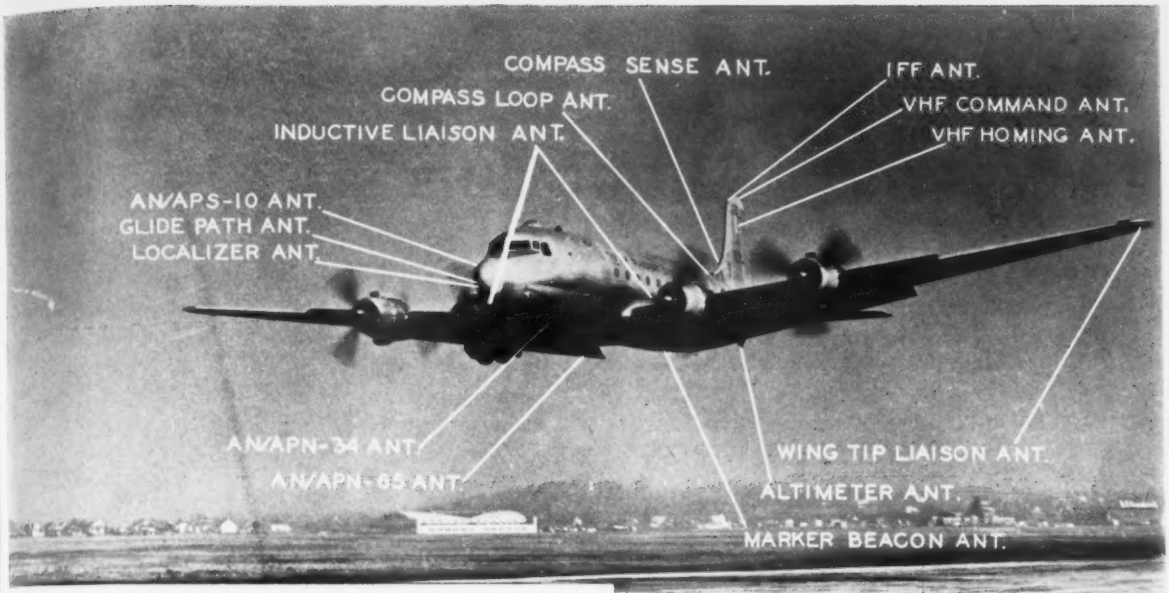
Therefore, we propose to build flush-mounted antennas—some in the wings, some in the fuselage—and we also propose to cut into the leading edges of the wings and to make recess-type antennas to be covered with fiberglas covers; or we propose to cut into the bottom of the fuselage and do the same thing. Some of our recess-type antennas may measure 3 ft. across, depending on the frequency used. The structural engineers tell us that they had counted distinctly on using the skin of the airplane to carry stresses and that we may not cut any holes larger than about 1 sq.in. However, it may be only $\frac{1}{8}$ in. wide, the rest to be made up by length. Also, they tell us that below the skin there are structures. There is just barely room to get those structures in, and all over the place there are controls, gas tanks, etc. In other words, the wing is full. The fuselage is full. There is landing gear, there is fuel, and their is either armament or passengers and luggage.

While all this may be amusing, it is an extremely painful situation to contend with. I should therefore like to propose another method that we have been able to put into successful operation at Martin. The method is to have a conference while the aircraft designer still has a wild gleam in his eye. The conference is not only with propulsion, aerodynamics, stress, weight, and armament people but also with electronics people. Not that electronics people wish to push themselves forward. They would just like to build a tolerable antenna. In modern high-speed aircraft, I doubt whether we could ever build a really good antenna, but one that is tolerable might be possibly arrived at.

Let us consider some other limitations on our antennas. There is temperature and erosion by outside factors. In normal propeller or jet-driven aircraft below the velocity of sound, there is usually a fairly cold environment once we get high up. It may be hot and moist near the surface, but that isn't too bad for some modern structural materials.

However, as soon as we begin to go past the barrier of sound—and it isn't really visionary to talk about that any more—we find that the shock wave and air friction produce high temperatures. We also have an exceedingly difficult problem of streamlining our antenna covers and of making them out of materials that will still retain some amount of strength at the temperatures encountered. Airplane designers have found rain and hail and snow erosion to be very bad, and, of course, the antenna designer suffers with them, particularly the man who trys to design the radome that covers the antenna in such a way that the radio waves go in and out but the atmosphere does not.

In summary, air-borne antenna design is a composite or hybrid science that combines the problems of the aircraft, the atmosphere, and the radio engineer. I should like to propose that all people connected with aircraft design and operation admit the antenna designer to their councils as early in the problem as possible. In that way we may be able to produce tolerable antennas, and I do not think we can ever hope to do much more than that.



ELECTRONICS FOR AIRCRAFT

(*Continued*)

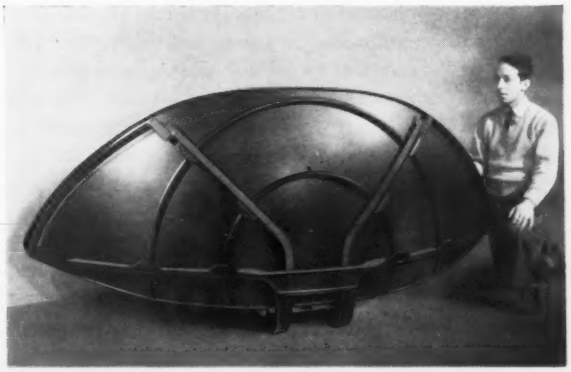
ANTENNA

It has only been a few years since we thought of aircraft antenna as a wire stretched between the wings and the tail of an airplane. Today, antenna has assumed shapes and sizes as varied as the electronic equipment with which it serves.

The advent of air-borne radar, with its attending scanning mechanisms, reflectors, and lenses, has done anything but lessen the headaches of the aircraft designer. By the same token, the development of radar and the ability to carry it into the air have advanced the progress of aviation immeasurably.

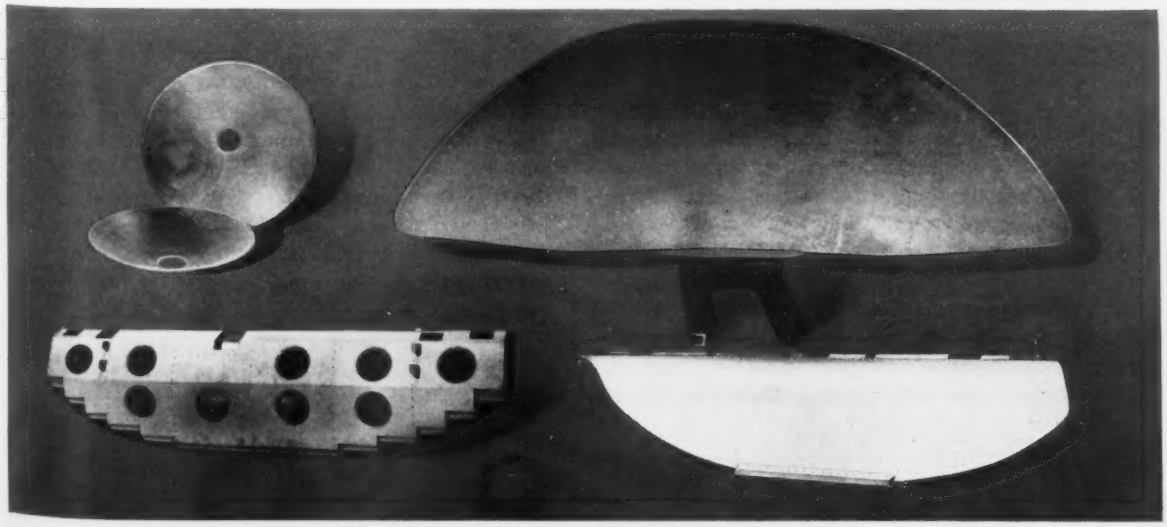
Here is a typical case where the electronics engineer and the airplane designer must closely coordinate their efforts.

(*Continued on page 42*)



The prolific number and varied types of antenna incorporated in the modern airplane are illustrated by the U.S.A.F. C-54 above. Some idea of the aircraft designer's problems may be visualized by a glance at the air-borne radar equipment at right and below.

Photos Courtesy Air Materiel Command and Brooks & Perkins, Inc.



Frequency Allocation for Aviation Electronics

EDWIN LEE WHITE*

Federal Communications Commission

THE PROBLEMS PECULIAR TO AIRCRAFT OPERATION as they relate to power supply, equipment design, and antenna installation have been covered by the previous papers in this issue. The problem of finding radio frequencies on which this equipment may operate is faced not only by those interested in aircraft operation but also by every potential user of radio. For this reason, the following discussion of that problem is not limited to aviation aspects but rather covers the broad field of the problems in frequency allotment.

When Heinrich Hertz first demonstrated the validity of Maxwell's prediction of radio waves, he had no thought in his mind of frequency allocation problems; nor did Marconi when he succeeded in spanning the Atlantic. These men were primarily interested in generating radio waves and making them work. Having succeeded in their efforts, the problem of frequency allocation arose. In these early days, it was simple. The question was merely what wave length to choose as distress channel for ships. The situation certainly is different now, but the basic pattern remains the same. Portions of the radio spectrum may lie fallow for years until someone finds a practicable means for generating frequencies of the required wave length and applying them to a useful purpose. Immediately thereafter comes the problem of the allocation of this portion of the frequencies among users.

The first successful attack on the allocation problem came in 1927. Prior to World War I, the point-to-point service, the ships, and the amateurs were the only ones making extensive use of radio. The spark, the arc, and the low-frequency alternator were the usual generators of radio-frequency energy. The vacuum tube had become a reality but had not been given general application. The amateurs had demonstrated the usefulness of the high frequencies for long-distance communication. The general speed-up of activities incident to war had given rise to large demands for communications, which in turn reacted to speed up radio research. Many devices and services had emerged from the laboratory and had been put to service in the few years of the war. It is hard to tell what particular item was of greatest importance; however, the development of the vacuum tube, making possible the broadcast industry and the design of selective vacuum-tube receivers, was undoubtedly among the most important. The new tools were adopted by the industries of all the countries of the world, and radio communication services grew by leaps and bounds. The increased number of simultaneous uncoordinated transmissions resulted in worldwide interference. The United States invited all nations to an international conference in 1927 to find a means to remedy the situation. International allocation of frequencies among users seemed to be the answer, and that portion of the radio spectrum was allocated which covered the frequencies for which apparatus was generally available. Possibly one of the major contributions to the growth of radio made by this conference was the establishment of a plan whereby frequencies were allotted to services. This was done in spite of the opinion of some nations that frequencies should be allotted on the basis of nationalities.

The international allotment table, prepared in Washington, was modified in 1932 and in Cairo in 1938. Between each of these meetings, there was a development of new apparatus that made possible the useful application of higher frequencies, which in turn produced a new group of potential users. Again we saw the pattern—the development of equipment for new frequencies, the application of the new frequencies to new uses, and the problem of their allocation to assure equitable distribution of the frequency spectrum among all potential users.

The Cairo allotments were scheduled to be reviewed in Rome in 1942. World War II intervened, and, as in every war, the radio experts of both sides were preoccupied in making the most useful application of the radio spectrum to the military effort.

World War II, as in the case of World War I, gave a tremendous impetus to research and development.

Presented at the Session on Electronics in Aviation—1, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* Chief, Safety and Special Radio Services Bureau.

Means were provided to make useful application of all frequencies up to 10,000 mc., and the way was paved toward the possible application of still higher frequencies. Noteworthy among the achievements was the development of a host of applications for pulse techniques to communication problems. Included in these were Radar and Loran.

After World War II, the nations of the world found themselves in much the same position as after World War I. All were operating new services for which no frequencies had been allocated, and the older recognized services were receiving interference. The United States again took the lead and in 1947 called a conference at Atlantic City to reconsider the existing Telecommunication Treaties, especially the Cairo Allocation Table. The table produced at that meeting has not, as yet, been wholly placed into effect.

At Atlantic City, it was found impractical to start a new list on the basis of the revision of the Cairo tables. As previously stated, a large number of services had come into being since the Cairo meeting, all demanding frequencies. Other services had expanded many fold; among these was aviation. The Cairo allocation provided only a small number of specific channels for exclusive aviation use, in bands of frequencies, 6 mc. or higher. These channels were suitable for low-speed continuous-wave telegraph transmission only and were only authorized for use over certain specific routes, such as Europe–North America over the Atlantic, Europe–North America over the Arctic, Europe–Africa, etc. It is needless to recount the growth of aviation during the war; not only is the number of frequencies provided by the Cairo tables inadequate but, in addition, the route pattern forecast is inappropriate and hand speed CW is woefully inadequate to move communications at a rate and in volume commensurate with the speed and density of modern aircraft operation.

It was found necessary at Atlantic City to recognize the facts not only as applied to aviation but also as applied to other services. In spite of the increase in ability to use new frequencies, the new services requiring long-range frequencies could only be recognized by withdrawing frequencies from other services, primarily from the band 2,000 to 30,000 kc. As a result of the negotiation, the fixed service lost a significant amount of the space previously allotted to it in this band. The aviation and broadcast services were the major beneficiaries.

It became evident at Atlantic City that it would not be possible to develop a detailed plan for the implementation of this new list, and the task was entrusted to an organization which the conference established and called the Provisional Frequency Board. In general terms, the task of this Board was to write a new "engineered" frequency list. In this new list the stations of the world were to be provided with that complement of frequencies which would be necessary for them to render the service for which they were established, all chosen in accordance with the table of allocation. The P.F.B. was unable to complete its task. Again the old pattern had emerged. The development of the new means for generating radio frequencies had developed new uses for radio and, in this case, apparently in numbers beyond the capability of the spectrum. Although the P.F.B. was able to engineer a list in some bands, in others it was confronted with requests for assignments running into hundreds of per cent of the number of channels available under standards of allotment which were applied to ensure substantially interference-free channels to all.

Under the Atlantic City arrangement, it was provided that the various services (such as aviation, broadcast, or marine) might be called upon to assist the P.F.B. in working out utilization plans for the frequencies assigned exclusively to them. Of all the services that held meetings, the aviation service was the only one that succeeded in preparing an assignment plan. This plan leaves much to be desired, but it is the opinion of the delegates to the Conference that it is the most equitable distribution that could possibly be made of the portion of the frequency spectrum given to the aviation service by the Atlantic City table.

Under the Atlantic City plan, the work of the P.F.B. and of the service meetings was to be approved by a Special Conference to meet about 6 months after the P.F.B. finished the engineered list. When it became obvious that this list would not be produced, an "Extraordinary Administrative Radio Conference" was called and was scheduled to meet in September last year. This Extraordinary Conference was supposed to complete the work of the P.F.B., writing rules as necessary so as to fit the requirements into the space available. Because of the present world situation, the Conference was postponed and is now scheduled to meet next August in Geneva. In the meantime, all the nations are exploring ways and means of getting 10 gal. of stated requirements into a 6-gal. jar.

So much for the problems involving those frequencies that we must consider from a world-wide point of view. Similar difficulties exist on those frequencies whose characteristics are local in nature. The development of techniques making practical the use of frequencies above 30,000 kc. have brought with them new uses for radio and, as a consequence, allotment problems.

The local character of these frequencies has permitted a new point of view to be adopted in considering their allotment. The use of frequencies capable of long-range interference restricted the total possible number of users to such an extent that many desirable uses could not be authorized. It was a generally accepted thesis that the use of radio should not be authorized when the purpose for which communications was desired could be met by wire. Further, the long-range frequencies were, and still are, only allotted for purposes directly connected with safety or which contribute, to a major degree, to the national welfare. With the possibility of using frequencies whose effects could be limited to the local area, it has become practicable to modify these premises to a large degree and thus satisfy many demands. For example, the microwave transmission sys-

tems now used by Western Union, A. T. & T., the railroads, and others are direct substitutions for services previously performed by wire. It was also possible to satisfy many industrial communication requirements by the use of radio, such as those involved in crop dusting with aircraft, in the management of large ranches, etc. Frequencies could be found in sufficiently large number to permit the widespread application of radio to the administration of the transportation systems of the country, such as the railroads, the busses, the trucks, and the taxicabs.

In addition to the possibility of localizing transmissions, these new frequencies also provide for wide-band systems of communication; thus television became a practical service. Multiplex systems providing large numbers of channels on a single frequency became possible—for example, pulse-time modulation communications systems.

The widening of the usable portion of the spectrum has not relieved the pressure on those responsible for allotment planning but rather has increased their headaches.

Even with the broader point of view just mentioned, there are many cases wherein the use of radio would be desirable from the point of view of the applicant for frequencies, but the number of equally qualified applicants, and their prospective communications, far exceeds the ability of the spectrum to satisfy their needs. Thus, the allocating authority must restrict the conditions under which the use of frequencies is authorized until the number of authorized users will fit into the space available.

Among the headaches is that which arose from the fact that some equipment was designed and produced without regard to the frequencies upon which it would operate. One of the most difficult problems of this nature involved certain industrial heating, in the design of which consideration was apparently not given to the fact that radiations from the equipment could not be confined and that such radiations interfere, or may interfere, with users of the radio frequency spectrum not concerned with industrial heating. As a result of this situation, there were months of negotiation leading to the establishment of the so-called "ISM" bands used for industrial, scientific, and medical purposes. After the bands were chosen, there were months of design and reconstruction in order to put equipment already manufactured into the appropriate portions of the spectrum. In another case, some military equipment was redesigned, ignoring the fact that the frequencies for which it was originally manufactured had been released from the wartime utilization and were occupied by other services. There was great consternation when the redesigners were ready to put the equipment on the market and found that there were no frequencies on which it could be operated. These cases are particularly unfortunate, since a simple inquiry at the Federal Communications Commission would have disclosed the facts of allocation and the necessary frequency adjustments could have been made during design and manufacture.

History would indicate that the users of radio and those who manufacture equipment to satisfy user demands must continually increase the efficiency of the use of the spectrum so that the needs of our growing economy can be met with the available frequencies.

In the use of frequencies, a great deal can be done to reduce the time on the air required for the transmission of intelligence and to reduce the number of communications required to pass an idea. As a beautiful example of wasted time, an aeronautical station operator sent this message to an aircraft. "Will you please repeat your last message? You were blocked out by another airplane and I did not get what you said." The use of the simple phrase "say again" would have been adequate. Similar redundant statements can be heard in every service.

Those in the aviation service will remember the time when it was felt necessary to keep each airplane pilot advised of the position and direction of flight of all aircraft ahead of him, behind him, above him, and below him so that each of them could determine the safest course and altitude to fly.

It is easy to see that, with an increasing number of aircraft in the air, the number of messages required will increase by geometric proportion, since the plan of any individual pilot might change the plans of six others and their decision would, in turn, react on each other, and so on. The tendency now is to analyze all such information on the ground and to develop a coordinated flight pattern and advise the pilot as to what course it is safe to pursue.

In most communications systems, those responsible for supervision can materially increase the capacity of their circuits without reduction in the intelligence transmitted or without use of means for higher speed transmission if they will analyze their operating problems as they relate to communications with this point in mind.

Another prolific source of increased utility of the present spectrum is the adoption of higher speed means of communications. The printer will handle a great deal more communication than manual telegraphy with very little increase in band width. Facsimile and voice communications have applications wherein the amount of intelligence transmitted per kilocycle band width occupied will exceed any other means. In designing a communication system, care must be taken in selecting the method of transmission most suited to the task to be performed.

Much is being done in adopting devices that provide for multiple use of the frequency. In the microwave systems that I have mentioned, extensive use is made of multiplexing. For example, a system may provide the linkage whereby it is possible for the dispatcher to talk to maintenance crews anywhere along the system. Provision can be made for intercommunications at will between many points and between many points and a central office. There may be channels for direct communications between the ends of the system. Provision may be made for telemetering service where readings can be taken of instruments at dozens of points and all

recorded at central headquarters. In fact, there may be provided along a single microwave system hundreds of communication channels employing several different methods of modulation.

Another simple form of multiple use of frequencies is the practice of providing simultaneous voice and printer communications on a single radio frequency without appreciable increase in band width or serious degradation of quality of the voice transmission. Possibly one of the most ambitious programs of this kind is involved in the "all-weather system of traffic control and navigation" proposed by the Radio Technical Commission for Aeronautics and now being implemented. One small phase of that program is the plan for the use of the band 960 to 1,215 mc., which is allotted primarily for distance-measuring systems. In order to accomplish all the various and sundry types of communications that are involved in moving aircraft in large numbers from point to point regardless of weather or route pattern, multiple use of equipment is being given fullest consideration. In this particular band, not only is provision made for the interrogation and reply involved in the distance measuring but also provision is planned for situation display, air-ground voice communications, airport surface navigation, azimuth and speed reporting, and approach and landing control. If the devices necessary to perform these functions were given separate frequencies, there would be no possibility of finding spectrum space. However, by the use of such measures as pulse-coding and pulse-multiplexing, as well as requiring the use of transmitting equipment having a high degree of stability and receivers of the maximum selectivity, the operational requirements may be met within the space available.

I will not attempt to give other examples of means that are constantly coming from the laboratories, or of the constant study of the use of radio and its application to specific problems, all with the end in view of increasing the effectiveness in the use of the radio spectrum. The task is endless. As our desires grow, the demand for communication grows. We have explored the spectrum from the extremely low to the super high, and, unless we can find some means to use negative frequencies as we use negative numbers, we will be faced with the necessity for continually increasing the services to be performed in the spectrum without increase in the space available. This may sound like asking the impossible. It is a challenge to the ingenuity of the scientist, the engineer, and the practical operator. We are now accomplishing the difficult. Since finding the answer to future expansion is impossible, it will only take a little longer.

Air Traffic Control

(*Continued from page 21*)

of Airport Surface Detection Equipment. The use of radar is likely in this connection.

"With regard to program implementation, current procurement programs will provide many of our more active air-traffic areas with Airport Surveillance Radar, Precision Approach Radar, Instrument Landing Systems, Automatic Direction Finders—both V.H.F. and U.H.F., and Air Traffic Control Interlock Systems.

"Navigation-wise, these programs may include omniranges, Distance Measuring Equipment, and various beacons and markers.

"As soon as available, in addition to these equipments, the system should employ the Radar Safety Beacon, Air Traffic Control Signalling System, Data Transfer and Display Equipment, Air Traffic Control Plotting Displays, Long-Range Radar, Remoted Scopes, Airport Surface Detection Equipment, and a Traffic Delay Predicter.

"In conclusion, the program and plan of the Operational Policy Group is presently being carefully studied by a mobilization planning survey group of the National Security Resources Board in order that implementation may be expedited as is consistent with mobilization and national defense requirements."

Packaging of Air-Borne Electronic Equipment

(*Continued from page 30*)

To conclude, those who are involved in the design and evaluation of new techniques of packaging should bear in mind that only actual trial by manufacture and use will finally decide the desirability of the various techniques proposed. This does not mean, however, that every means at our disposal should not be used to anticipate fundamental objections to new techniques before the actual trials are made. Because of this it is important to avoid the easy way of omitting accessibility from subminiature designs. It seems clear that the experience of the past makes the success of any such design highly improbable either for the manufacturer or the user.

ELECTRONICS FOR AIRCRAFT

(Concluded)

NAVIGATIONAL EQUIPMENT

Radio, with all of its ramifications, has unquestionably been the greatest single contribution electronics has made to aviation. From the time the first two-way radio between an airplane and the ground was successfully tested by Lieutenant Mauborgne and H. A. Dargue in 1914, the progress of both military and commercial aviation has paralleled the technical advancements made in electronic communication and navigational equipment.

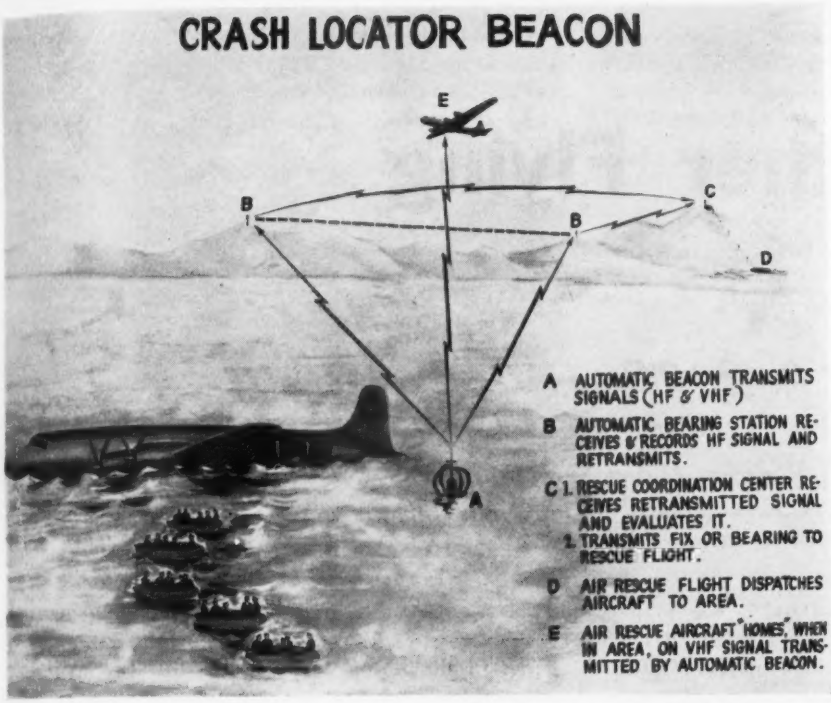
Who prodded whom into each technical improvement over the intervening years is of no significance now. The aircraft engineer's demands for, and contributions to, new electronic products perhaps has balanced the voluntary improvements proffered by the electronics industry.

What *does* matter is this!

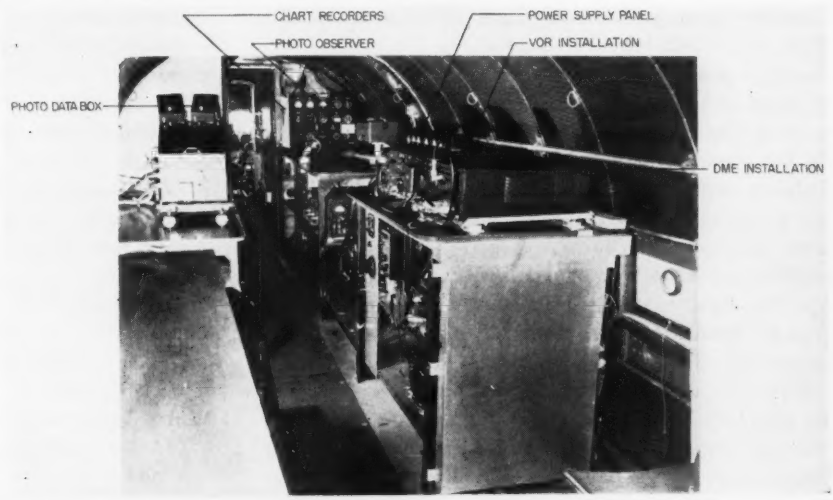
Today's airplane is controlled by, built around, and dependent upon electronics. There are unlimited possibilities for the further development of present and new products in this field. The continued close cooperation between engineers and manufacturers of electronic equipment and of aircraft must inevitably result in advantages to both. The peace of tomorrow's world may also depend upon it.

A nonmagnetic fabric shelter, known as a "Radome," has been developed to protect radar equipment atop the tower from the weather. The fabric dome, supported by dehydrated pressurized air, does not interfere with operation of radar scanning mechanisms.

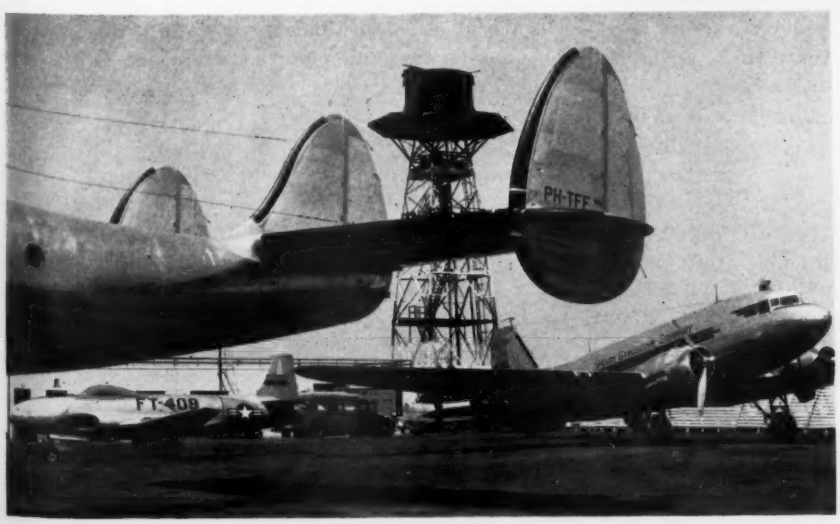
Continued research is bringing about constant improvement and simplification of the pilot's navigational problems. A typical example of this is the Sperry Zero Reader shown below.


CRASH LOCATOR BEACON
E
B
B
C
D
A
A AUTOMATIC BEACON TRANSMITS SIGNALS (HF & VHF)
B AUTOMATIC BEARING STATION RECEIVES & RECORDS HF SIGNAL AND RETRANSMITS.
C 1. RESCUE COORDINATION CENTER RECEIVES RETRANSMITTED SIGNAL AND EVALUATES IT.
2. TRANSMITS FIX OR BEARING TO RESCUE FLIGHT.
D AIR RESCUE FLIGHT DISPATCHES AIRCRAFT TO AREA.
E AIR RESCUE AIRCRAFT "HOMES" WHEN IN AREA, ON VHF SIGNAL TRANSMITTED BY AUTOMATIC BEACON.

Electronics plays a major role in rescue efforts in event of an airplane crash or a forced landing. Pictured here is an artist's conception of the principal operational phases connected with the use of the Crash Locator Beacon developed by the U.S.A.F.



Evaluation of VOR-DME installations by Airborne Instruments Laboratory, Inc., required a flying laboratory containing the complex array of electronic and photographic recording equipment, communications links, and navigational equipment shown on the right.



Symbolic of the role of electronics in aviation is this MacArthur Field view of a KLM Constellation, a U.S.A.F. TF-80 jet, and a corporate DC-3 in the shadow of a microwave omni-radio-range and distance-measuring equipment antenna. This OBD system, developed by Sperry Gyroscope Company, is currently being evaluated by the All-Weather Flying Division for the Air Navigational Development Board.

All-Weather Flying

By

Captain R. C. Robson*

Captain R. C. Robson

Impressions of the All-Weather Flying Symposium, Electronics—2 Session, I.A.S. Nineteenth Annual Meeting

The Nineteenth Annual Meeting was in part devoted to a symposium on "All-Weather Flying." Colonel J. Francis Taylor, U.S.A.F., Chief, All-Weather Flying Division, presided over this session and was assisted by a group of men recognized as being tops in this field.

Early in the meeting it was stated that the pilot's point of view has been too often overlooked. The purpose of this symposium was to bring this point of view to the attention of I.A.S. members with a request for help on certain matters. The main topics that came up for discussion were electronic and visual landing aids, radar, and, of course, weather.

Although it has been talked about for many years, all-weather flight is still far from being a common practice. Yet the need to operate under all conditions is already present in military and commercial aviation.

The symposium was opened with a spectacular film on approach lights and runway markings, a project of the Air Transport Association and the Air Line Pilots Association. It was composed of pictures taken by the Landing Aids Experiment Station, Arcata, Calif., and the Sperry Gyroscope Company. Over 50 scenes were included of actual approaches in bad weather. Some of the flying was done with visibilities as low as 150 ft. and ceiling zero. A running commentary by Capt. J. F. Gill, Air Transport Association, brought out important features of the picture.

The problems connected with landing after a low approach are difficult, if not impossible, to comprehend unless one is present during the actual procedure. The A.T.A.-A.L.P.A. film comes closest to bringing non-fliers into the cockpit. Indeed, some scenes are so impressive that audiences occasionally help to fly the plane by use of "body English" and exclamations.

In the past decade a vast amount of work has gone into the design of approach lights. They have been rightly termed the "missing link" needed to connect the runway with that point in space where the guidance of electronic devices ends. Three basic configurations exist: a single row of lights extending from the left edge of the runway; a single row from the runway centerline; and two rows that converge toward the center of the runway (the so-called "slope-line" lights).

Pilots list several important factors that must be considered in the design of any lighting system.

(1) Identification—Approach lights must be easily identifiable from the highest possible altitude in bad weather.

(2) Alignment—The lights must define the runway centerline in the simplest configuration requiring no mental interpretation.

(3) Distance Remaining Indication—There must be a visual indicator in the approach zone to warn of imminence of runway threshold. This distance gage must be far enough from the end of the runway to allow the pilot time to prepare for landing and must be visible under the poorest conditions.

(4) Threshold Identification—There should be positive and distinctive runway threshold lighting, including imminence of threshold—i.e., a clear overrun area, lighted properly, just before reaching the threshold and then different lighting on the runway immediately after the threshold.

(5) Glare Elimination—Lights on the approach, threshold, or runway must not blind the pilot.

(6) Contrast—There should be lights in two colors at the threshold—red for the overrun area and green to mark the beginning of the runway. In addition, bold painted markings must be provided on the runway surface to distinguish sod from pavement.

(7) Runway Lighting—The runway must be evenly lighted—no "hot" spots or blanks—and the lights must be visible when off to one side or high on the approach.

Many airports are located in heavily populated areas, and city lights, (such as well lighted streets) can occasionally be mistaken for approach or runway lights. Approach lights (multiple-row configuration) have also been mistaken for runway lights in the past

* Captain, American Airlines System.

and with appropriate results. The surest method of preventing this confusion appears to be the use of condenser discharge lights in combination with a single row of fixed burning units. The condenser lights serve as a "come-on" to the pilot. They are powerful enough to penetrate several hundred feet of fog, and the high-speed flash is too rapid to affect the eye. These features make them ideal for use with the regular sealed-beam lights.

Airports equipped with left side approach lights occasionally have runway lights knocked down on the *right* side of the runway. Until recently, there was no explanation for this; nor was its significance understood. The answer, an optical illusion produced by the left side lights, was clearly evident in the film. On approaches made when there was no visibility beyond the approach lights, the plane, although perfectly aligned in an automatic approach, appeared to be on a collision course with the lights. Normal tendency would be to make a right turn. The smashed runway lights were proof that pilots have a normal tendency. It is apparent, therefore, that left side approach lights do not provide alignment under all conditions. The use of centerline lights eliminated any consideration of angular measurement, since the plane flies directly over them and alignment with the runway is assured.

On many approaches, it was impossible to anticipate the beginning of the runway, the exact dilemma of the pilot who must prepare for landing. One centerline system attempted to correct this by using several long crossbars evenly spaced along the approach path. It was evident in the film, however, that one could not tell which bar was in view, and, consequently, there was no information as to distance remaining to the runway. Only on the configuration using a single crossbar was there definite proof of the location of the airplane with respect to the threshold. This single bar, located 1,000 ft. from the end of the runway gave the pilot a visual indicator by which he could determine the propriety of continuing the landing operation or pulling out. The term "go, no-go gage" aptly describes this necessary feature.

The need for adequate threshold identification was shown in several pictures when, without warning, the approach lights simply ended. One had the distinct feeling of "Oops, we missed the runway." This is precisely the position of the pilot.

The glare factor was apparent in approaches to Idlewild using unfiltered "slope-line" lights. By a bit of clever photography the Sperry cameramen were able to show simultaneously the pilot's eyes and cockpit instruments, as well as a view ahead of the plane. At night, the lights were dazzling, and the pilot kept squinting and ducking his head back into the cockpit to prevent blinding. Use of red filters eliminated the glare, but the resultant decrease in intensity scored the need for condenser discharge units.

A "before and after" sequence of landings pointed up the need for runway markings. On approaches to an unpainted runway, during the low-contrast conditions of daylight fog, it was impossible to distinguish pavement from sod early enough to align the plane and land. The only clues to the runway were the magnetic numerals at the threshold and tire marks on the asphalt. When the same runway was provided with bold painted markings at the threshold, centerline, and border, it stood out plainly. Such markings not only proved the runway but allowed the pilot to align the plane with the runway and maintain this alignment throughout the landing roll.

ALL-WEATHER FLYING SYMPOSIUM PANEL: *Electronics experts participating on this Panel included Chairman, Col. J. Francis Taylor, Jr., U.S.A.F., Chief, All-Weather Flying Division, Wright Patterson Air Force Base; Ernest A. Cuttrell, Air Line Pilots Association; B. A. Denicke, Air Navigation Development Board, John F. Gill, Air Transport Association; Comdr. Robert E. Laub, U.S. Navy; D. S. Little, American Airlines System; B. R. Moore, Civil Aeronautics Administration; S. P. Saint, Working Group No. 5, Air Coordinating Committee.*

SPERRY GYROSCOPE COMPANY
FLIGHT RESEARCH DEPARTMENT
RUNWAY MARKING LAYOUT
26
R
DETAIL "A"
SIDE STRIPE
DISTANCE MARKER
THRESHOLD MARKING
NOTE - ALL MARKINGS ON BOTH SIDES OF RUNWAY ARE SYMMETRICAL
NOTE - SIDE STRIPES PLACED TWO FEET FROM EDGE SO THAT THE PAINTING MACHINE CAN OPERATE ON THE RUNWAY
NOTE - THIS AREA HAS BEEN ALLOWED SO THAT THE PAINTING MACHINE CAN MANEUVER ON THE RUNWAY
SUGGESTED NON-SKID RUBBER MARKING MATERIAL
THE SUGGESTED NON-SKID RUBBER MARKING MATERIAL IS A MIXTURE OF TEN PARTS LIME AND ONE PART WHITE (BLEACHED) CEMENT AND WATER UNTIL THE MIXTURE REACHES THE CONSISTENCY DESIRED FOR APPLICATION BY BRUSH OR SPRAY. A SLIGHT INCREASE IN THE CEMENT CONTENT MATERIALLY ASSISTS IN THE ADHESIVE QUALITY OF THE MIXTURE
THIS FORMULA IS USED FOR RUNWAY MARKINGS IN CANADA. IT HAS PROVED TO HAVE EXCELLENT NON SKID PROPERTIES, AND IT IS EASILY RENEWED

Runway Marking Layout: *By the Flight Research Department of the Sperry Gyroscope Company. The suggested nonskid runway marking material consists of ten parts lime and one part white (bleached) cement. Add water until the mixture has reached the consistency desired for application by brush or spray. A slight increase in the cement content materially assists in the adhesive quality of the mixture.*

This formula is used for runway markings in Canada. It has proved to have excellent nonskid properties, and it is easily renewed.

Night approaches at LaGuardia showed the confusion produced by low-powered, ragged-looking, directional runway lights. The lights went by as sporadic flashes and provided no information whatsoever. The wide-angle lights of uniform intensity used at Idlewild outlined the runway clearly and gave good speed and guidance information.

The opinion of air transport people was expressed in Captain Saint's comment that A.T.A. feels the A.L.P.A. configuration is by far the best, with its simple straightforward presentation. Air Force and Navy authorities agreed with the importance of lights but have not yet formed any fixed opinions. Special military considerations, such as installation at advance bases and carrier operations, are limiting factors in the use of approach lights and place greater emphasis on runway markings.

A discourse on approach lights always brings up the subject of the relationship between electronic and visual landing aids. Accordingly, the question was raised as to why landings are made manually instead of automatically like the approach. Discussion brought out the fact that automatic landings have been made, but that they can be extremely rough. There is considerable experimentation to develop a flare-out system to correct this, but the advantages gained will be paid for in the addition of equipment, such as sensitive altimeters. Since ceilings below 100 ft. occur only a small percentage of the time, it may be difficult to justify the elimination of a paying passenger to add the equipment. Automatic landing devices must be made fail-safe or pilots will not approach too close to the runway. Both Captain Gill and D. S. Little stressed the fact that the calculated risk in currently available equipment cannot be accepted for air-line operations. Only under laboratory conditions is it possible to operate to 100-ft. and $^1/_2$-mile visibility. The panel was of the opinion that time spent on making present devices more reliable rather than in developing new gadgets might be of greater benefit.

The newly devised radar traffic-control system of Working Group 5, Air Coordinating Committee, was aired in an impromptu talk by S. P. Saint, backed up by Comdr. A. W. Wuerker, U.S.C.G., Chairman of the Group, and B. A. Denicke and B. R. Moore. The know-how for producing a better method of controlling traffic in the terminal area was available some time ago, but it slumbered until decisions on important fundamentals could be reached among the interested groups. Key decision of Special Working Group 5 was to use radar as the primary tool for the job, since it would not add more black boxes to airplanes.

The present network of airways can feed planes into a terminal area faster than they can be handled by the airport and its approach facilities. In the new system, long-range radar will be used for rough spacing of aircraft entering the area. The terminal radar will then clear ships over existing navigational facilities and place them on final approach with proper sequencing. Major advantages of radar are that the controller can anticipate the movements of planes and that the planes therefore occupy a smaller space than with present methods. This has the all-important effect of shortening the landing interval. The traffic pattern will be tailored to suit each individual airport, and with present equipment the system can handle up to 40 aircraft movements per hour. This must be stepped up to 120 movements to meet possible air-traffic requirements of the future.

A radar system such as this does not contemplate "holding" as it is presently known. By controlling the speed and by varying the track of each airplane, the controller can produce the required flow onto the runway. In trials at Wright-Patterson Air Force Base, 56 landings were made with an average interval of 1.7 min. This included a "lost" airplane, with improper radio frequencies, which was "found" and landed in 7 min. without disrupting traffic. The planes in the pattern ranged in speed from the F-80 to the C-47.

The most urgently needed device to ensure the operation of this system is the air-borne beacon or transponder. Without this radar beacon there cannot be 100 per cent control of aircraft, since all radar can be knocked out by certain types of weather. A simple, dependable beacon that could provide an identification code when requested would suffice for the present.

An interesting problem brought out by Commander Laub is that of carrier operations at sea. A primary concern of the carrier is the handling of large numbers of aircraft all arriving at once with limited fuel supply. Any pure radar system would break down under the communications load. A maximum interval of 30 sec. between landings is required. An operation of this type needs both air-borne and shipboard automatic computers and automatic posting, as well as many other things.

The usefulness of air-borne radar is still being debated among the air lines. S. P. Saint expressed the opinion, held by many other pilots, that air-borne radar will some day be as important as the power plant or landing gear. Actually, it is needed now on high-speed airplanes to navigate around turbulence and dangerous weather and also to dodge ice. Air-borne radar is less useful for terrain clearance except in unknown or particularly rugged territory. For the pilot who flies a regular route, it could be used to a limited extent for navigation, but it would not replace any other navigation facilities; nor is it useful in preventing mid-air collisions. As an aid for low approaches, air-borne radar is satisfactory to approximately 200 ft. only, roughly the limits of present radio facilities. The biggest drawback in the use of this device is the daylight viewing problem in the cockpit.

Ironically, this All-Weather Symposium was held at the tail end of a period of bad weather which succeeded in grounding many airplanes thoughout the country. The culprit was freezing rain. As Colonel Taylor remarked, ground icing, especially from freezing rain, is one of two major problems in aviation which need solv-

(*Continued on page 173*)

This formula is used for runway markings in Canada. It has proved to have excellent nonskid properties, and it is easily renewed.

Distance-Measuring Equipment for the Terminal Area

JOSEPH LYMAN* and GEORGE B. LITCHFORD†

Sperry Gyroscope Company

Introduction

THE FUTURE GROWTH of air traffic and even the effective utilization of certain types of aircraft are dependent upon having an adequate traffic-control system that is capable of expansion. Such recent developments as the turbojet at one end of the speed range and the helicopter at the other have produced new requirements that must be considered along with the requirements of the conventional propeller-driven aircraft in the solution of the air-traffic problem. Fuel consumption of the turbojet aircraft is such that it cannot tolerate air-traffic delays that are often accepted by the propeller-driven aircraft. The speed limitations and maneuvering characteristics of the helicopter must also be considered.

It appears that problems such as these can only be solved by the cooperative effort of almost all branches of the aeronautical sciences. The power-plant and airframe designers must consider controllability of air traffic as important to their future designs as other characteristics of the aircraft. Airport designers must consider the configuration of runway layouts and ramp facilities to handle higher density traffic with less delays. Improved runway design can materially reduce air-traffic bottlenecks by providing multiple turn-off strips, wider landing strips, and taxiway configurations to avoid congestion on the airport. Electronic engineers must provide improved means of aircraft navigation-guidance systems so that the efficiency of air-traffic control can be improved while retaining adequate standards of safety.

This paper deals with a part of the relationship of electronics to air-traffic control. Aircraft position measurement and reporting of position to the ground are fundamental to air-traffic control. Without adequate means of determining the position of several aircraft and relating this information to the respective prescribed flight plans (schedule and track) for each aircraft, not even the simplest form of control can be achieved. As position determination becomes more accurate, closer tolerances in track guidance and schedule control can be maintained. Assuming that runway and ramp facilities are adequate, the electronic navigation-guidance system becomes the limiting factor in establishing the capacity of a terminal area. By improving the electronic position-measurement technique, the capacity of a terminal area can be increased.

Position determination can be accomplished by several electronic means. The most practical method for short-range determination appears to be the polar-coordinate system in which the angle from a reference direction and the distance from the center determine the position. The accuracy with which angle and distance can be measured thus determines the accuracy with which position is known, and the accuracy of position determination is one of the main factors in establishing the rate at which air traffic may flow.

An improved angular measurement system has been described in a previous paper.[1] The present paper describes a distance-measuring technique that is technically compatible with the azimuth system, permitting integration of equipment and joint use of the same radio channels and thus conserving radio spectrum.

The techniques for the measurement of distance by radio means are well known and well established. Radar, loran, and shoran, all of which measure distance, are in everyday use. More recently, a specialized type of distance-measuring equipment (D.M.E.) has been evolved in which distance is measured between the airborne equipment and a suitably arranged ground transponder. The result is displayed automatically in the aircraft on a special dial calibrated in miles. The only essential difference between the presently labelled D.M.E. and the older devices is one of utility. All use pulses of one type or another. The newer D.M.E. indicates distance automatically on a dial, while the older methods used a cathode-ray tube which required interpretation.

The D.M.E. coming into use today has been developed specifically to handle many of the problems in the en-route portion of flight and was not conceived with the rigid requirements of terminal area navigation in mind. This paper will presently describe a different type of D.M.E. designed so as to be capable of meeting the anticipated operational requirements. A detailed study of these requirements indicates that standards of accuracy of measurement considerably beyond those required for en-route flight must be established. It is also more important to integrate the technique and the actual apparatus of distance measurement into an overall plan of terminal area guidance and con-

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* Department Head, Aircraft Radio Research Department.

† Engineering Section Head, Aircraft Radio Research Department.

trol so that the essential quantity of position determination is achieved by the cooperative use of both azimuth and distance-measuring equipment.

By handling the problem as a whole we are able not only to achieve important savings in apparatus weight and complexity but also to take up a minimum possible amount of the moderate radio-frequency spectrum assigned to the navigation of aircraft. This latter consideration has great significance because of the large number of important terminals throughout the world and the high ratio of the number of using aircraft to each terminal.

Because of these considerations, it now seems best to review once again the general problem of air-traffic control before discussing the specialized requirements that any D.M.E. in the terminal area must meet. Navigational problems in the terminal area are so complex that a full understanding must be had of the overall problem before any particular piece of radio equipment can be properly evaluated, discussed, or described. Accordingly, the operational requirements of the terminal area which affect the distance-measuring part of a navigational system will be discussed at some length before any mention of the characteristics of distance-measuring equipment itself will be made.

A Discussion of the Traffic Problem

As air traffic approaches the airport and the terminal area surrounding it, the traffic density increases rapidly. Traffic on any particular air route between cities may be light, but, since all air routes tend to converge on major terminal areas (such as New York, Washington, and Chicago), the density of air traffic around one of these major terminals is much greater than on any particular air route. Fig. 1 illustrates this basic problem. Six airways are shown entering a terminal area (30 to 50 miles radius around the airport). By adequate instrumentation, each airway can have several tracks disposed either horizontally or vertically. For example, ten altitude layers are often employed for air traffic, using the altimeter for defining the vertically separated airways. It is also possible to use a polar-coordinate system to define horizontal parallel airways.[2]

Six horizontal parallel airways with ten altitude layers can provide 60 lanes of air traffic. These can be employed to solve some of the problems previously mentioned, such as the large speed differential existing between different types of modern-day aircraft. Air-traffic lanes can be assigned on a speed basis, giving express tracks to high-speed aircraft. Other lanes might be used for avoiding adverse weather such as icing conditions and rough air. Traffic intersections, such as the familiar cloverleaf pattern used on parkways, require additional lanes for maneuvering into a new airway. The use of many properly spaced airways will also result in much greater longitudinal separation between aircraft. In this manner, the traffic density on any particular lane is greatly reduced and safety of the traffic-control system is thereby enhanced.

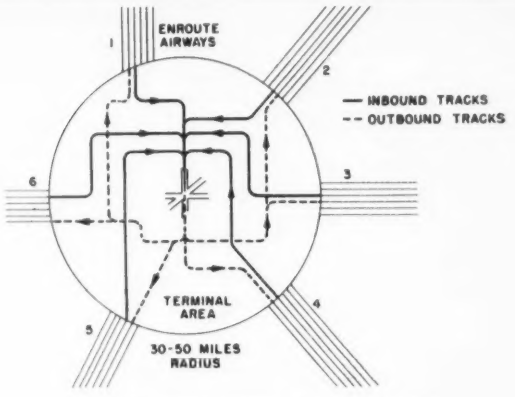

FIG. 1 - SIX AIRWAYS SERVING A TERMINAL AREA

Let us now examine the traffic in the terminal area. There is evidently greater need for multiple lanes or air tracks in the terminal area than in the en-route areas. However, the available volume of space around the terminal is much restricted as compared to that in an en-route system where airways can spread out horizontally and vertically to greater extent.

The altitudes available to terminal-area traffic are limited, since it is advisable to restrict aircraft to a vertical angle equal to or less than that of the glide path at 30 miles. This is to avoid the necessity of aircraft being forced to dive into the glide path because of being too high. A $2^1/_2°$ glide path is approximately 7,000 ft. high at 30 miles. Obstructions and flight rules often limit the lowest usable altitude to approximately 1,500 ft. Thus, the operationally useful vertical region is 5,500 ft. in depth at 30 miles and approximately 2,000 ft. deep at 15 miles. The useful altitude region becomes even less as the aircraft approaches the airport. Of course, on final approach the useful altitude region is only a few feet in depth.

It can be seen, therefore, that altitude separation cannot be employed extensively in the terminal area, even though much closer vertical tolerances can be maintained, and that horizontal separation must be relied upon primarily for dense traffic operation, since the horizontal area in the terminal region is much greater, by a ratio of 200 to 1, than the available vertical area.

Keeping in mind the limitation on vertical separation, let us proceed with the investigation of the traffic in the terminal area. Several en-route systems, each with multiple lanes, may feed into a terminal area having restricted airspace. As many tracks as possible must be available between any terminal-area entry point and the final-approach entry gate to provide a track length that would entail the minimum delay for scheduling aircraft into the final approach. Use of many tracks also prevents two aircraft with small separation from following the same track for any distance until it becomes absolutely necessary on the final approach. On top of all of these requirements, it is necessary to provide

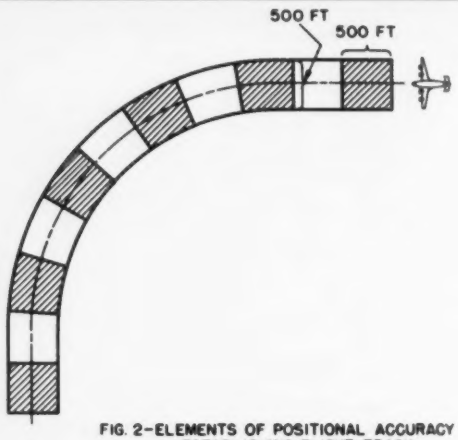

FIG. 2—ELEMENTS OF POSITIONAL ACCURACY ESTABLISHING FLIGHT TRACK

tracks for outbound traffic. Outbound and inbound traffic require separate tracks for safe operation.

From the foregoing it can be seen that with air traffic pouring in from several multiple-lane en-route airways to a restricted volume of airspace in the terminal area, this airspace must be utilized as efficiently as possible. It is evident that the electronic means that defines a particular block of airspace must be capable of defining it to the greatest accuracy possible. If the airspace coordinates cannot be precisely defined, the resulting additional latitude in separation between tracks, the inability to maintain close longitudinal spacing on the same tracks, and the inability to measure track speed adequately will greatly reduce the traffic capacity of a terminal area.

The requirements for the accuracy of the distance-measurement element of a polar-coordinate system can now be summarized. It appears, in general, that the traffic employing the terminal area tracks should avoid the same common air track for as long as possible. This permits the separation between aircraft on the same track to be greater than the final approach landing interval. By having several horizontal tracks in the terminal area and utilizing the volume of this region as efficiently as possible, the density on any particular track will be greatly reduced. Thus, even where consecutive aircraft are arriving from the same airway, independent tracks can be assigned to each aircraft, depending upon speed differential, traffic-coordination delays, etc. Consequently, the time-separation interval on any particular track can be allowed to be perhaps three or four times that of the final-approach separation interval.

Let us take, for example, an accuracy of ±250 ft. for defining the position of the aircraft. Using this figure, the air track will be defined by blocks 500 ft. square in the horizontal plane, as illustrated in Fig. 2. In order to measure the *changing position* of the aircraft on the track so that its future position can be predicted, the rate of change of position, or track speed, must be determined. From considerations based on the final-approach requirements, a track-speed measurement accuracy of approximately 2 per cent is indicated.[1] Since the errors in position determination are normally unpredictable in their nature, it would be necessary to traverse 25 elements in order to get a track-speed measurement. Thus, it will take a track roughly $2^1/_2$ miles long to establish a speed measurement to the desired accuracy.

Several measurements of speed will be necessary for deceleration (consider jets entering the terminal area 600 m.p.h., for example) for regulating the traffic so that it will mesh properly at the point where all multiple tracks in the terminal area converge into the final approach, and for scheduling crossovers at track intersections in the terminal area wherever necessary. Since several separate speed measurements must be made, a track length of perhaps 15 times that necessary to make a single speed measurement is required for the final approach scheduling. This would imply a track approximately 35 miles long for decelerating the aircraft, getting it under adequate control, and coordinating its schedule with other aircraft.

All of these measurements and the necessary changes in speed should be accomplished at a safe distance from the entry to the final approach in order to provide time and space for maneuvering the aircraft back on another track in case adequate control (involving correct heading, correct track speed, correct position, etc.) has not been established. For a first approximation, it appears that the ±250-ft. positional accuracy requirement in the terminal area would be adequate for aircraft entering the final approach at a rate of approximately 2 per min.

Once all aircraft are on the final approach and are being guided by the radio landing beams, a single precisely defined air track must be maintained in both the vertical and horizontal planes. Longitudinal separation between aircraft is also of prime importance, since the final approach track may be from 5 to 10 miles long, causing aircraft with different final-approach speeds to come dangerously close together if some means of maintaining separation on the final approach is not provided. Since the final approach normally is basically a radial path, the accuracy of the distance-measuring portion of the polar-coordinate system determines the accuracy with which proper separation can be maintained. A typical final-approach problem will illustrate the order of the accuracy required.

Assuming an approach speed of 120 m.p.h. and a separation interval of 30 sec., aircraft are spaced with a 1-mile separation over the 10-mile common final-approach track. Let us assume there is a final-approach speed difference between consecutive aircraft of ±2 m.p.h.

If the first aircraft is 2 m.p.h. slow and the second aircraft is 2 m.p.h. fast, there is a closing rate of 4 m.p.h. over a 10-mile track. Since the aircraft is on the 10-mile track for approximately 5 min., the closing rate of 4 m.p.h. is equivalent to a distance of one-third of a mile or 10 sec. of the approach separation interval. If a separation of as little as 18 sec. exists at the entry gate,[1] the separation could get as low as 8 sec. at

touchdown, which is possible because the tolerance in position determination (±250 ft.) results in schedule and speed tolerances, an extremely dangerous situation.

It therefore appears that ground-speed measurement must be made to a greater accuracy than ±2 per cent on the final approach and that the interval of measurement must be decreased to allow sufficient time for corrective action. As a first approximation, it appears that on the final approach the ground speed must be measured to better than ±1 per cent, that each ground-speed measurement must be made in approximately 15 sec., and that the distance must be measured to an accuracy in the order of ±25 ft.

Distance-Measuring Techniques

Thus far this paper has presented a number of the operational requirements for a positioning-determining system and the resulting accuracy specifications for the measurement of distance. It is now necessary to describe a method for meeting these requirements.

Almost all radio distance-measuring systems employ a means for measuring the time of flight of a radio wave between two points. The propagation velocity of radio is precisely known and is, for all practical porposes, a constant value. The problem in designing radio distance-measuring equipment is to use this property of radio transmission to achieve the greatest accuracy possible and to do so with an economy of the radio spectrum. The techniques of continuous-wave and intermittent continuous-wave transmissions can be applied to the distance-measuring problem in such a way that both high accuracy and maximum conservation of radio spectrum are achieved.

A radio wave travels approximately 186,000 miles in 1 sec. Thus, in 1 millisec. a radio wave travels 186 miles. An aircraft 93 miles from a ground station transmitting a radio signal to the ground station, which then retransmits the signal to the aircraft, will receive the signal 1 millisec. later (93 miles to, and 93 miles from, the station equal 186 miles). If the aircraft is at a distance of 0.93 miles, it will receive a signal back 1/100 millisec. later. Thus, it can be seen that, to measure distance to a few feet, exceptionally accurate methods of time measurement are involved.

Another way to state the problem is to say that if the aircraft located at 93 miles transmits a 1,000-cycle tone, it will receive this tone modulation back 1 cycle later. If the cycles were to be numbered and the outgoing and incoming signals compared at the aircraft, number one cycle would be received during the same interval of time that number two cycle was being transmitted. If an electrical circuit measured the phase angle between the outbound and inbound signals, a 1-cycle difference, which is equivalent to 360° of electrical phase angle, would be noted. If the aircraft moved to 1 per cent of the distance (0.93 miles), as in the above case, the phase angle between the transmitted and received signal would be 3.6°. The electrical phase measurement can readily be accomplished by employing various types of phase-measuring devices. These devices are often called "phase meters," "goniometers," or "phase shifters" and are simply electrical yardsticks for measuring the electrical phase difference between two signals of the same frequency.

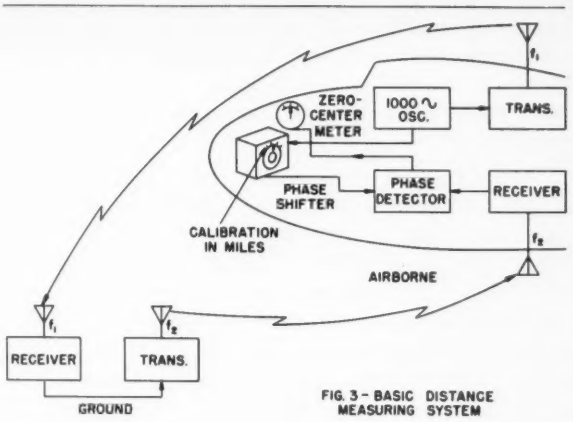

FIG. 3 – BASIC DISTANCE MEASURING SYSTEM

Fig. 3 illustrates the basic techniques for phase measurement. Distance can be determined by adjusting the phase-shifting device until the phase between the inbound and outbound signals are apparently equal, as indicated by a zero-centered meter connected to a phase-detector circuit. The phase-detector circuit is an electronic device that produces a d.c. signal whose polarity and amplitude is proportional to phase difference over narrow ranges of phase angle. The amount of phase shift introduced in the aircraft is equivalent to the phase shift in the radio transmission loop to the ground and return and, in turn, is equivalent to the distance to the ground station. The phase shifter can be calibrated directly in miles, and thus an operator in an aircraft can determine his distance to the ground by adjusting the phase-shifting device and reading the dial setting when the phase-detector signal is zero.

Such a simple system does not meet all the desirable operational objectives of distance-measuring equipment, since manual adjustment and zeroing of the instrument is necessary. Also, a system such as described has limitations in accuracy due to imperfections in the phase-measuring process itself.

In the employment of such equipment where one station is air-borne and the other is on the ground and where two radio channels are involved, an error in phase measurement of as much as ±3° can be expected under operating conditions. Under ideal laboratory conditions, an accuracy of ±1/2° has been obtained. However, such an accuracy could not be obtained under normal operating conditions. Thus, experience has indicated that one cannot expect much more than ±3° phase-angle stability through such a system. Using the 1,000-cycle tone modulation and the phase-shifter illustrated previously, this would be equivalent to a little less than 1 mile. The automatic measurement of distance on a dial or a map-type

presentation appears desirable, since the pilot cannot be expected to be making manual adjustments under changing conditions of distance. Thus, there appears the need for improved accuracy and automatic instrumentation.

The automatic measurement can be accomplished simply by amplifying the signal to the zero-centered meter and causing it to drive a motor that mechanically rotates the phase-shifter. The motor will turn the phase-shifter in the correct direction and stop when the signal from the phase-detector has reached zero. The phase-detector determines the direction the motor should turn. As the aircraft changes distance, the phase angle is changed, and this causes the motor to drive in the correct direction to bring the electrical phase-detector signal back to zero. Thus, a pilot observing the automatically positioned shaft of the phase-shifter can determine his distance.

The equipment limitations that do not permit accurate measurement of phase angle in such air-borne equipment can be overcome to a great extent, and the goal of measuring distance to an accuracy of a few feet can be achieved. In the previous example the 1,000-cycle signal produced a phase-angle difference between the outbound and inbound signal of from 0° to 360° for a distance change of 0 to 93 miles. Beyond 93 miles, the signal goes through another cyclic change, but the second cycle cannot be detected from the first, since, in the phase measurement equipment described, 180° of $46^1/_2$ miles would appear the same as 360° plus 180° or a distance of $139^1/_2$ miles. The ability to resolve ambiguity in a distance of 93 miles is not difficult under most conditions. This is particularly true of the terminal area, where it is assumed that other navigational means have guided the aircraft to its boundaries. Thus, for a 30-mile maximum range (the terminal area), the 1,000-cycle distance-measurement signal can be employed without fear of ambiguities. If, now, the accuracy is inadequate, as it appears to be, a measurement signal of a higher frequency (a shorter distance) will supply greater measurement accuracy. Assuming the ±3° electrical phase errors in the system, much higher accuracies can be achieved if an 18,600-cycle tone modulation is employed in the measurement of distance. A phase shift of 360° will then occur for a distance of 5 miles and will repeat itself every 5 miles. A pilot using such a measurement, however, could not determine, for example, whether he was at 5, 10, 15, or 20 miles.

By combining the low-frequency measurement with the higher-frequency measurement, a coarse and fine system is achieved. This coarse frequency will resolve the 5-mile ambiguity, and, at the same time, the higher frequency will give a more precise measurement of distance. This general technique improves the distance accuracy by the ratio of the frequencies. In this case, the improvement is approximately 18 times. In practice, both coarse and fine systems are used simultaneously and jointly. The automatic servo shaft

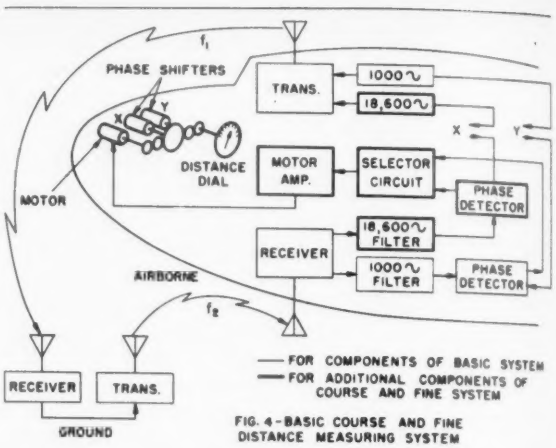

FIG. 4 - BASIC COURSE AND FINE DISTANCE MEASURING SYSTEM

positions out the coarse system and then switches to the fine system. No action on the pilot's part is required for any of these operations. The pilot merely knows the distance more accurately by the two-frequency method.

Physical equipment based on these principles has been constructed by the Sperry Gyroscope Company and is now undergoing flight trials by the All-Weather Flying Division of the U.S.A.F.

Fig. 4 illustrates the basic coarse and fine system. By such a means, ambiguities are resolved and the necessary accuracy acquired. The addition of a second or even a third frequency does not complicate the system much over the simple single-frequency system, since almost all parts of the radio loop, transmitters, receivers, servos, etc., are common to the two- or three-frequency systems. Thus, an increase in accuracy to almost anything required operationally can be achieved, including the extremely high accuracy required for final approach.

It is important to note that discrete fixed frequencies are employed for the measurement, thus permitting the use of narrow-band filters adjusted to the measurement frequencies. In this manner, the overall bandwidth of the distance-measurement system is reduced and the signal-to-noise ratio is improved. These discrete frequencies utilize only a small percentage of the available modulation spectrum of the air and ground radio transmission and reception equipment.

It is therefore possible to supply part of the radio loop by using another facility. The D.M.E. herein described has been integrated with a 5,000-mc. omnirange system[1] so that the omnirange transmitter supplies a radio channel to all aircraft employing the system, and the omnirange receiver in the aircraft receives both the distance-measurement signal and the omnirange signal. Modulation for these functions and several other functions are filtered off at the aircraft's receiver and are treated independently by measurement circuits. Thus, economy of radio spectrum and equipment are an important part of this D.M.E. technique.

Multiple Aircraft Use of the D.M.E.

It is obvious that if 50 aircraft are all transmitting a continuous distance-measuring tone modulation on the same radio channel, interference between signals will be encountered. To avoid interference, each aircraft utilizes the radio channel only a fraction of 1 per cent of the time, thus reducing this problem to a point where it no longer can affect the system in operational use. If each aircraft used the radio channel one-third of 1 per cent of the time, 300 time intervals would be available. By scheduling the transmission time of each aircraft, a multiple aircraft service is provided.

In practice, this scheduling is accomplished by azimuth scanning of the terminal area in a manner similar to a rotating searchlight beam. As the scanning device passes through North, a signal is transmitted to all aircraft employing the service to notify them that they are to transmit at a time proportional to their azimuth position. The azimuth scan is made in 6 sec. The aircraft employ their omnirange receiver for determining their azimuth and, thus, the time at which they can measure distance. For example, an aircraft at North responds instantly. An aircraft at 90° responds 1.5 sec. later; an aircraft at 180°, 3 sec. later; etc.

The response time is 1/60 sec., during which the radio loop between the air and ground is closed and a distance measurement is made. This permits 18,600÷60 or 310 separate cycles of the higher-frequency modulation to be measured in the phase-comparing circuit. The phase-measurement circuit receives a signal for each cycle so that, essentially, the distance is the average of the 310 consecutive measurements during the 1/60 sec. This signal is then stored in an electrical circuit, and the next few seconds are used to position the control motor to the new position.

Since a precise measurement of distance is made each 6 sec., it is possible, after four or five measurements, to establish the rate of change of distance. This signal is also fed to the servomotor to smooth out the indication. If a measurement is lost because of interference or loss of signal, the rate of change of distance "remembered" in the electrical circuits is employed to move the phase measuring device to the new assumed position. This can continue for as many as four or five consecutive missed measurement periods. Thus, smooth and accurate data are fed to the pilot's display. By the time-sharing process described and the employment of rate and rate memory in the servo systems, a distance-measurement system is provided which will not be saturated under the highest possible anticipated utilization rate.

Instrumentation of Distance Information

It is possible to present distance data to the pilot in several forms. These include such standard-type indication as multiple-hand clock-type indicators, Veeder-Root counters, electrical meter movements, synchro repeaters, etc. In the terminal area, complex configuration of the flight tracks under dense traffic conditions is more the rule than the exception. It appears impossible for the pilot to fly a track as illustrated in the accompanying figure by means of an independent azimuth dial, distance dial, and heading dial.

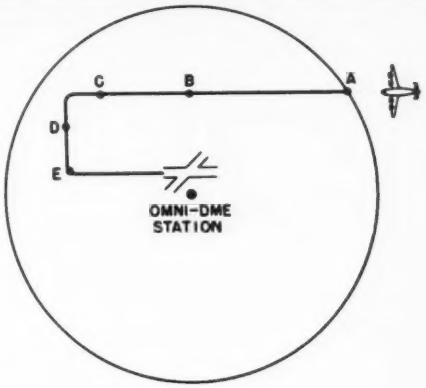

FIG. 5-TYPICAL TERMINAL AREA TRACK

For example, in Fig. 5, if the aircraft proceeds down the track as illustrated at point "A," the azimuth is changing slowly but the distance is changing at nearly the ground-speed rate. At point "B," azimuth is changing at a high rate but distance changes are nearly zero. At point "C," azimuth again is changing only slightly but distance is changing at nearly ground-speed rate but in the opposite direction as compared to point "A." At point "D," the direction of flight has been changed so that distance is again changing only slightly and azimuth is changing rapidly. Even more complex relations of distance, azimuth, and heading exist during a precision turn such as at point "E," the turn into the final approach. Under wind conditions where the heading must be computed for a given ground track, more complexities are added.

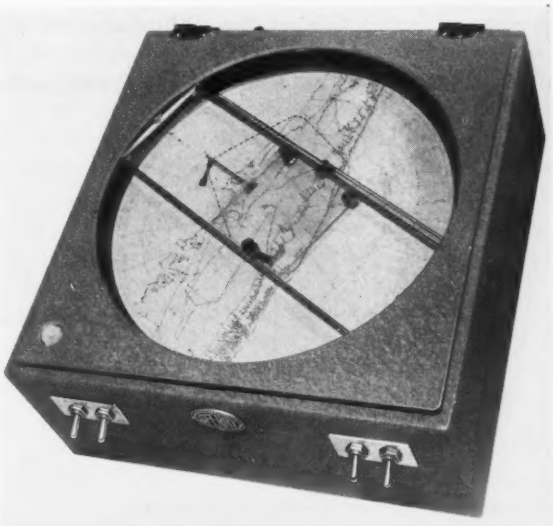

Fig. 6. Pilot's indicator.

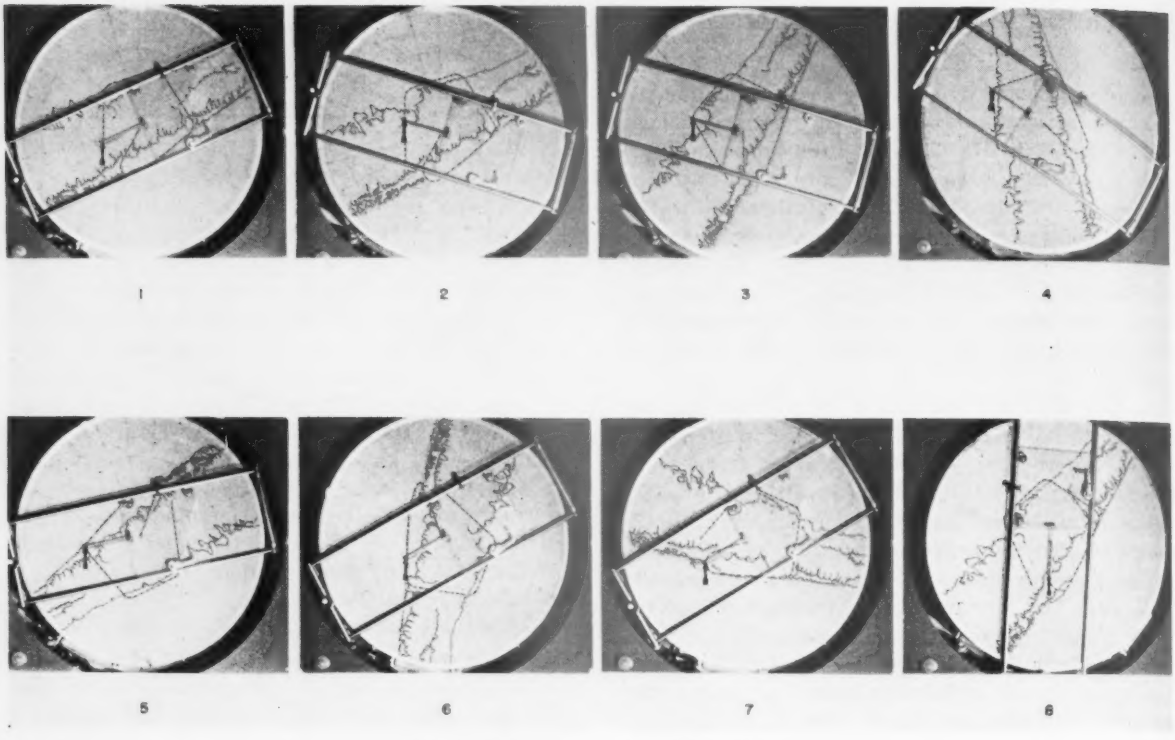

FIG. 7. Series of frames from 16-mm. film.

"Course-line" computers have been developed to convert omni-D.M.E. data to straight-line tracks which are interpreted by the pilot on a right-left meter. However, such computers are not satisfactory in the terminal area, since (1) several straight tracks are involved, (2) precision control turns are needed, (3) complex curved tracks are a necessity in dense traffic, and (4) the pilot has only a track-error signal and has no idea of where he is on the flight track or what is coming up in the future.

These problems are alleviated by the employment of pictorial graphic computers, which consist primarily of a map display showing the flight track and the position and attitude of the aircraft relative to the flight track. A small crab automatically positioned by the D.M.E. and azimuth servos moves across the map and presents the position of the aircraft relative to the flight track. The crab has an arrow indication that is connected to the Gyrosyn* Compass so that the aircraft's heading and position are both shown on the map relative to the flight track. This automatically presents drift to the pilot. These pictorial computers have received considerable development and appear to be the most promising approach to date for the solution of the aircraft instrumentation problem in the terminal area.

A pictorial computer display† employed with the 5,000-mc. Omni-Range D.M.E. is shown in Fig. 6 and will be reviewed as an example of the integration of the distance display with azimuth. This display consists of three small servomotors that position the crab in azimuth, distance, and heading relative to the ground station shown at the center of the display. All servos are automatic and move smoothly with changing position and aircraft attitude. As the aircraft proceeds down the flight track, the presentation is much like that which the instructor of a link trainer observes when a student is working out a radio-range problem. If the student could observe the instructor's display, he could undoubtedly do a superior job.

The small crab that presents the position of the aircraft has a recording stylus that electrically records the actual path of the aircraft on facsimile paper, showing deviations from the flight track, drift angle, and overall performance. This is particularly useful in determining small angles of drift, since the narrow recorded line will show a track deviation of only a few hundred feet. If the heading is incorrect for the flight track the drift is shown by the angle between the recorded flight track and the desired flight track. Correction is easily approximated and the normal bracketing involved in flying radio flight tracks is greatly reduced by a display using this memory feature.

The following series of photographs (Fig. 7) show such a pictorial display at discrete intervals along a given flight track. As the aircraft flys along the flight track, the display presented to the pilot is indicated by the photographs.

* Reg. Trade Mark of The Sperry Corporation.

† Developed under the auspices of U.S.A.F. All-Weather Flying Division and Watson Laboratories.

Summary and Conclusions

In the terminal area, anticipated operational requirements lead to consideration of new techniques for traffic control. Both azimuth and distance measurement of aircraft position must be properly combined in air and ground equipment. It has been shown that measurement of distance, particularly on the final approach path, may require accuracies up to ±25 ft. A satisfactory method for achieving accuracies of this order of magnitude is to use phase measurement of a decade set of modulations on a radio frequency carrier that also delivers azimuth information.

It has also been shown that mere measurement of azimuth and distance with separate dial indications is not sufficient to permit satisfactory pilotage. It has been shown how a map-type display is an improvement. Such a display combining azimuth, distance, and heading allows the pilot to fly any required complex flight track.

It is concluded that:

(1) In addition to an accurate azimuth system, a precision D.M.E. is required for air traffic guidance and control in the terminal area.

(2) Limitations of radio spectrum and operational requirements force combination of D.M.E. and azimuth functions in system design.

(3) Map-type display as described is desirable for proper utilization of this information by the pilot.

References

[1] Lyman, J., and Litchford, G., *A Precision Omnidirectional Radio Range for the Terminal Area*, Aeronautical Engineering Review, Vol. 9, No. 6, p. 16, June, 1950.

[2] Lyman, J., and Litchford, G., *The Effect of Position Determination on Air Traffic Control*, presented before Joint I.O.N., R.T.C.A., and R.T.C.M. Meeting, September 19–21, 1950.

Problems of Standardizing Electronic Equipment for Aircraft

(*Continued from page 27*)

automatic radio direction finders to provide the pilot with heading information along with the four-course range track information. Final refinement added to the low-frequency system was the 75 mc. markers. The air-borne radio equipment usually carried for the low-frequency system totaled two range receivers, an automatic direction finder, a medium frequency transmitter-receiver unit, and a marker beacon receiver.

Transition aircraft electronic systems now partly installed, or scheduled for installation by the 1953 transition program, consist of a V.H.F. transmitting-receiving unit, two V.H.F. omnidirectional radio range-runway localizer receivers, one marker beacon receiver, one low-frequency automatic direction finder, distance to the station measuring equipment, shortest course computers, and a private-line communication system or a second V.H.F. communications unit. From the minimum of three or four aircraft radio equipments used with the four-course ranges, the improved air traffic control program during the transition period will require a minimum of eight aircraft radio units to be carried in air passenger service.

Today, the distance-measuring equipment, the second omnireceiver, the V.H.F. communications, the computers, and the private-line communication are to be installed in the aircraft to complete the transition program. The C.A.A. installation of the ground facilities, which must precede the air-borne installations, are well along. Basic V.H.F. communications and visual omniranges are now operating, with distance-measuring equipment being scheduled for installation. These primary C.A.A. ground aids, operating with the air-borne equipment, provide the basic transition electronic program. The private line and the course computer will be added to the basic systems.

Air-borne electronic equipment characteristics can now be established for all units of the transition period except the private line. However, with 2 or 3 years required to design and to manufacture and another 2 years to install the equipment in operating aircraft, the program is now 2 years behind. Today, we must step up our implementation to keep pace with air traffic requirements by planning to provide electronic equipment space in new aircraft and to modify in service aircraft to facilitate the electronic equipment installation. These provisions must be for electrical power, aircraft wiring, accessible controls, antenna systems, equipment space, and extra instrument mounting space.

To control our expanding air traffic, we must use, in the air and on the ground, an efficient and dependable electronic navigation system to handle the high-speed traffic. This means better planning and better use of better electronic equipment. The engineer has, by his design of electronic devices, provided cognizant operational planning bodies with the vision to create a "common system" of air traffic control. The engineer can design the electronic equipment for this common system. The final success of the ultimate common plan of the air traffic control depends upon the continued unvarying vision of the cognizant operational planning organizations.

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

Tables of the Theodorsen Circulation Function for Generalized Motion

By

Yudell L. Luke and Max A. Dengler
Midwest Research Institute

Important in all stability, aeroelastic, and flutter problems is the Theodorsen $C(k)$ function. Tables of this function are well known if the motion is harmonic. Heretofore, tables of the Theodorsen function for generalized motion have not been available. In this report, the latter tables are given for a range that should be sufficient to meet the needs of aerodynamicists. W. P. Jones has given a discussion of the generalized Theodorsen function, but his results appear incorrect, for, in his analysis, the Theodorsen function as derived by approaching harmonic motion from the side of stability and from the side of instability is distinct. If the Jones analysis were true, the nonuniqueness of the Theodorsen function would imply that the Bessel functions are not continuous, which is indeed false. The difficulty is clarified in this paper.

The Turbulent Boundary Layer in a Compressible Fluid with Positive Pressure Gradient

By

Carlo Ferrari
Cornell Aeronautical Laboratory, Inc.

The turbulent boundary layer in compressible flow is investigated for the case where there is a pressure increase in the direction of motion in order to determine its effect upon: (a) the velocity distribution at an arbitrary cross section of the layer, (b) the variation of the thickness of the layer as one progresses along the boundary and the calculation of the corresponding drag coefficient, and (c) the phenomenon of separation of the stream from the wetted wall.

A check, resulting in close agreement, is made of the theory by comparing the velocity profiles predicted on this theoretical basis with those obtained in experiments, at low speed, under the influence of pressure gradients. A further numerical application is worked out for the case of a supersonic (Mach Number = 1.5) undisturbed stream velocity, but no experimental data at such high speed are at present available for confirmation.

Note on Bending of Thick Sandwich Plates

By

George Gerard
New York University

A system of equations describing the bending of thick isotropic sandwich plates is developed. The thick-plate system is required when a characteristic length such as a buckle wave length is of the order of magnitude of the sandwich thickness. When the characteristic length is large, the thick-plate system reduces to the ordinary thin-plate system.

A Minimum Energy Solution and an Electrical Analogy for the Stress Distribution in Stiffened Shells

By

L. A. Goran
McDonnell Aircraft Corporation

The governing equations that can be used in numerical procedures for the stress analysis of stiffened shells are developed. The development is based on the usual assumptions of airplane stress analysis: that the ribs are rigid in their own planes, that stringers carry only axial load, that webs carry only shear load, and that average shear flows between ribs are obtainable from a consideration of axial load differences in the stringers. The mathematics of the solution, which is based on the principle of minimum strain energy, is facilitated by the use of the method of Lagrangian multipliers.

The problem considered is a generalization of that solved by Duberg in that effects of taper and curved shear webs are considered, while Duberg's treatment excludes the effects of taper and considers only flat webs.

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A simple electrical analogy to the stiffened shell problem is presented, and the method for its application is briefly discussed.

A numerical example illustrating the application of the method to a swept plate is presented in the Appendix. The solution is obtained by the use of the governing equations and also by a numerical solution of the equivalent electrical circuit.

Comparisen of Theoretical and Experimental Results for the Turbulent Boundary Layer in Supersonic Flow Along a Flat Plate

By

Carlo Ferrari
Cornell Aeronautical Laboratory, Inc.

On the basis of experimental results, it is found necessary to restrict previously obtained theoretical data for the boundary layer arising from supersonic flow along a flat plate (placed parallel with the free-stream velocity vector) to an "inner" region, while a different type of solution is formulated for the "outer" region of the boundary layer, the characteristics of which depend appreciably on the distance in the direction of the flow. The theory now conforms with the experimentally determined fact that the drag coefficient decreases with increasing Mach Number.

A Superposition Method for Calculating the Aeroelastic Behavior of Swept Wings

By

R. B. Brown, K. F. Holtby, and H. C. Martin
Boeing Airplane Company and University of Washington

This paper presents the development and application of a method for solving aeroelastic problems on sweptback wings,

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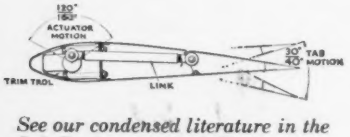

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primarily suitable for use by aerodynamics and structural design engineers. This method, called the Superposition Method, separates the aerodynamic and structural calculations, making it possible to use either theoretical or experimental determinations of spanwise loading and to account for induction effects. The method has been developed principally for use in design calculations where simplicity and rapidity of solution are primary considerations.

First, certain selected initial twist distributions are applied to the wing, and, for these, the spanwise loading is determined and the elastic deflections computed. Any arbitrary loading may then be calculated by superposition of these initial effects, plus the requirement of equilibrium between elastic and aerodynamic forces.

The Superposition Method can be used to solve the usual aerodynamic problems arising in longitudinal and lateral stability and control and to provide structural design criteria. Application of the method to these problems is discussed in the second part of this paper. In applying the method, once certain parameters have been calculated the solution to a large number of specific problems follows at once by application of the superposition principle.

Preprint No. 292

Determination of Rocket Motor Heat-Transfer Coefficients by the Transient Method

By
Stanley Greenfield
North American Aviation, Inc.

An experimental procedure has been developed to measure gas film heat-transfer coefficients in rocket motor combustion chambers and nozzles. The procedure utilizes the transient temperature rise of the uncooled segmented walls of a rocket motor to determine the rate of heat transfer.

This "transient method" was used to determine axial variation of film heat-transfer coefficients of gases at temperatures up to 3,000°F. flowing through a de Laval-type supersonic nozzle at rates typical of rocket motor operation. Experimentation results of 107 tests are presented.

Forty-nine tests were conducted with high-pressure air at 1,400°F. and at mass velocities varying between 1.4×10^5 and 6.8×10^5 lbs. per ft.² hour. The remaining 58 tests were conducted on an oxygen-ethyl alcohol rocket motor of 1,000-lb. nominal thrust by passing the combustion gases through the test nozzle at flow rates of between 3.5×10^5 and 11.3×10^5 lbs. per ft.² hour and at estimated temperatures of 3,000°F. Experimental values

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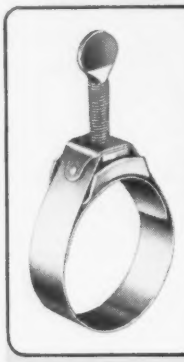

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Three-Dimensional Shock-Wave Reflections

By

E. Migotsky and M. V. Morkovin

University of Michigan

Reflections of steady shock waves from three-dimensional bodies are analyzed by applying the sweepback principle locally along the intersection between shock and body. It is found that the mathematical analyses of two important special cases—namely, a plane shock intersecting a circular cylinder and a conical shock impinging on a plane surface—are identical because of the underlying similarity of local geometries. In both cases, it is concluded that some type of Mach reflection must occur over part of the body even if regular reflection is possible at the point where the shock first reaches the body. Furthermore, the existence of an expansion wave originating on the lee side of the circular cylinder is indicated. The practical significance of these phenomena and their possible modifications in presence of a boundary layer are briefly discussed.

Transient Loading of Wide Delta Airfoils at Supersonic Speeds

By

John W. Miles

University of California at Los Angeles

The indicial admittance of a pointed wing, bounded by two supersonic leading edges and a straight trailing edge and located in an otherwise uniform supersonic flow, is calculated on the basis of linearized theory. This result is applied to the calculation of the lift and moments on a "wide" delta airfoil due to a sudden change of angle of attack, a uniform, sharp-edged gust, an impulsive gust, and sharp-edged and impulsive gusts having antisymmetric linear velocity distributions over the span. The response of a two-dimensional airfoil to an impulsive gust also is calculated. These results are given in the form of algebraic formulas and curves.

The Laminar-Turbulent Transition in a Boundary Layer

By

H. W. Emmons

Harvard University

A theory of transition from laminar to turbulent flow is developed from some new observations of the transition phenomena. Every point of a body is turbulent a fraction of the time, and a formula is derived for this fraction in a phenomenological manner. Application of the theory to available flat plate data gives some insight into observed effects and shows the way to additional experimental results required.

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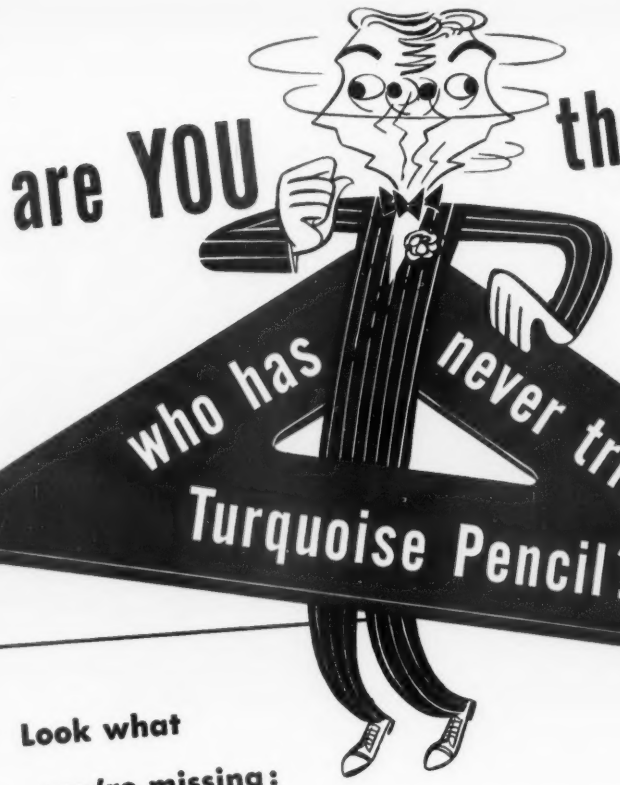

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		Member Price	Nonmember Price
337	Problems of Standardizing Electronic Equipment for Aircraft—Charles R. Banks.	$0.35	$0.75
336	Some Meteorological Problems Indicated for Jet Transport Operation at 40,000 Feet—H. T. Harrison.	0.35	0.75
335	Recent Investigation of Temperature Recovery and Heat Transmission on Cones and Cylinders in Axial Flow in the NOL Aeroballistics Wind Tunnel—G. R. Eber.	0.50	0.85
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325	Packaging of Airborne Electronic Equipment—Orville M. Dunning.	0.35	0.75
324	An Impulse-Momentum Method for Calculating Landing-Gear Impact Conditions in Unsymmetrical Landings—R. T. Yntema.	0.50	0.85
323	Theoretical Investigation of Several Types of Single-Degree-of-Freedom Flutter—Harry L. Runyan, Herbert J. Cunningham, and Charles E. Watkins.	0.50	0.85
322	Exploratory Wind-Tunnel Investigation of Wings and Bodies at M = 6.9—Charles H. McLellan.	$0.50	$0.85
321	Similarity Laws for Slender Bodies of Revolution in Hypersonic Flows—Stanford E. Neice and Dorris M. Ehret.	0.35	0.75
320	The Effect of Changes in Altitude on the Controlled Behavior of a Gas-Turbine Engine—S. C. Himmel and Richard P. Krebs.	0.50	0.85
319	Desirable Longitudinal Flying Qualities for Helicopters and Means to Achieve Them—F. B. Gustafson.	0.50	0.85
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314	Comparative Significance of Transport Safety Statistics—Rudolf Modley.	0.35	0.75
312	Practical Aspects of Turbojets in Transport Aircraft—R. T. Holland and E. L. Auyer.	0.35	0.75
311	Damping in Pitch of Bodies of Revolution at Supersonic Speeds—C. B. Smith and Beverly J. Beane.	0.50	0.85
310	On the Stability of Two Dimensional Laminar Jet Flow of Gas—S. I. Pai.	0.65	1.00
309	Frequency Allocation for Aviation Electronics—Edwin Lee White.	0.35	0.75
308	Allowable Compressive Stresses in Aircraft Structures—B. E. Gatewood and E. L. Williams.	0.50	0.85

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Preprint Department, Institute of the Aeronautical Sciences

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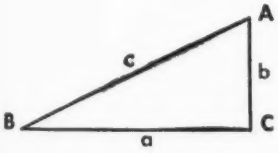
LITTLE THINGS ARE IMPORTANT!

Arma Electrical Resolver



Making important things little is a militarily vital objective of the accelerated engineering activity which characterizes Arma. Making them little and interchangeable and more accurate...all at the same time.

An example of advancing miniaturizing accomplishment is the new lighter, more accurate and interchangeable Arma electrical resolver. This is one of the computing components that replaced a formidable aggregation of gears, bearings and slides previously used in fire-control equipment to solve the trigonometric functions. It is the "thinking" mechanism in modern military instrumentation which solves such gun-laying equations as $a = c \sin A = c \cos B$ instantaneously.

The mechanical resolvers of World War II have since given way to the electrical. Application of the new miniature Arma electrical resolvers to the needs of all the Services is widening as rapidly as accelerated engineering can push it. This is another way Arma engineers work to help make America safe against those who wish to destroy it.

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I.A.S. News

(*Continued from page 7*)

1950 Safety Contest Closes with North American and AiResearch in Front

The National Safety Council's Aeronautical Industries Section Safety Contest for the 1950 calendar year came to a successful close with most of the contestants finishing with rates lower than those of a year ago.

North American Aviation, Inc., won the distinction of capturing both the first and third spots among the winners. AiResearch Manufacturing Company, Division of The Garrett Corporation, placed second. North American's Downey, Calif., plant experienced a frequency rate of injuries sustained during this period of 1.57 per million man-hours; AiResearch had a frequency rate of 1.60; and North American's Los Angeles plant came through with a 1.86 rating. The 1950 average rating for the twelve participating companies that completed the contest was 2.73. These particular concerns reported a total exposure of over 183,500,000 man-hours and a total of 502 injuries.

As first-place winner, North American's Downey plant will receive an appropriate trophy. Winners of the second and third places are to receive certificates.

Heat Transfer and Fluid Mechanics Institute's Fourth Annual Meeting

The Institute of the Aeronautical Sciences is listed among the sponsors of the 1951 Heat Transfer and Fluid Mechanics Institute, whose Fourth Annual Meeting is to be held at Stanford University on June 20–22, 1951.

The 3-day meeting will consist of six sessions of three papers each. Due consideration will be given to the problems in thermal radiation; conduction; convection; mass transfer and combustion; ideal compressible and incompressible flow of gases and liquids; and the various aspects of pipe, channel, and boundary-layer flow.

All of the 18 papers to be presented will be preprinted in full. Complete sets of these preprints will be on sale during the meeting. Registration fee for the 3 days will be $3.00. However, students who present evidence of their status will be admitted gratis. Further information on details of the meeting of the Heat Transfer and Fluid Mechanics Institute are available from A. L. London, Department of Mechanical Engineering, Stanford University, Stanford, Calif.

In addition to the I.A.S., the following organizations are also sponsoring this 3-day meeting: California Institute of Technology, Stanford University, University of California, University of Santa Clara, University of Southern California, and American Society of Mechanical Engineers (including the Applied Mechanics Division, Gas Turbine Power Division, Heat Transfer Division, and Hydraulics Division).

News of Members

▸ **Dr. John C. Cooper** (M.), Member, Institute for Advanced Study, Princeton, N.J., has been appointed Director, Institute of International Air Law, McGill University of Montreal, Canada. Dr. Cooper intends to spend half of his time at Princeton, but he will take up residence at McGill when the Institute opens this autumn.

▸ **James H. Doolittle** (H.F.), Vice-President and Member of Board of Directors, Shell Oil Company, was named special part-time consultant to Gen. H. S. Vandenberg, Chief of Staff, U.S. Air Force, on matters pertaining to the research and development of aircraft.

▸ **I. M. Laddon** (F.), Director and Consulting Engineer, Consolidated Vultee Aircraft Corporation, has been elected Chairman of the Executive Committee, Board of Directors, Convair.

▸ **Edward C. Wells** (M.), Vice-President—Engineering, Boeing Airplane Company, has been elected a member of Boeing's Board of Directors.

APPOINTED BENDIX PLANT MANAGER

C. V. Johnson (A.F.) has been appointed Manager of the Mishawaka (Ind.) plant, Bendix Products Division, Bendix Aviation Corporation. Mr. Johnson, who was formerly Administrative Engineer and Manager of Landing Gear Engineering, first came to Bendix in 1929. He made a survey of aircraft landing gear then in use which eventually led to Bendix's entry into that field.

Members on the Move

This section has been instituted to give information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

Franklin C. Albright (M.), Manager, Landing Gear Engineering, Bendix Products Division, Bendix Aviation Corporation. Formerly, Staff Engineer, Bendix Products Division.

Rex Anger (A.M.), Aviation Safety Agent—Aircraft Factory, Second Region, C.A.A. Formerly, Aviation Safety Agent, Seventh Region, C.A.A.

Hal T. Baber, Jr. (T.M.), Stability and Control Branch, Pilotless Aircraft Research Division, Langley Aeronautical Laboratory, N.A.C.A., Va. Formerly, Trainee, American Can Company.

Joe Banche (T.M.), Structures Engineer, Consolidated Vultee Aircraft Corporation. Formerly, Graduate Student, University of Illinois.

William B. Bergen (M.), Vice-President and Chief Engineer, The Glenn L. Martin Company. Formerly, Chief Engineer, Martin.

Donald H. Blose (T.M.), Project Control Engineer, Aircraft and Guided Missiles Section, Wright-Patterson Air Force Base, Ohio. Formerly, Vibration and Flutter Engineer, Dynamics Branch, Wright-Patterson A.F.B.

Private First Class Fred W. Bristol, Jr., 9330 T.S.U., O.G.M.C., Redstone Arsenal, Huntsville, Ala. Formerly, Engineering Department, City of Warwick, R.I.

Staff Sergeant Theodore C. Carnavos, U.S.A.F., Junior Project Engineer (G-E J47 engine), Power Plant Laboratory, Rotating Engine Branch, Headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Ohio. Formerly, Student.

Juney Dillenbeck-Grantham (A.M.), Manager, Budgets and Forecasts, Scandinavian Airlines System, Stockholm, Sweden. Formerly, Superintendent, Budget

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Frequency range, 0 to 10,750 Mc./Sec.
V. S. W. R., 1.5 maximum
Insertion loss, .5 decibels or less at 3,000 Mc./Sec.
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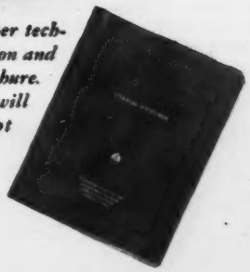

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NAMED TO NEW POST

W. Thomas Stark (M.) has been appointed Executive Vice-President and a Member of the Board of Directors, United Aircraft Products, Inc. In this capacity he will supervise the general operation of the company. Prior to this move, he was associated with Wright Aeronautical Corporation, Curtiss-Wright Corporation, for 13 years as Project Engineer in Charge of Fuel Metering and Ignition, as well as Turbine Control and Accessory Development. Mr. Stark is a graduate of Rensselaer Polytechnic Institute.

and Cost Control, Overseas Division, S.A.S.

LeRoy F. English (M.), Design Engineer, Lockheed Aircraft Corporation. Formerly with LeRoy F. English Company, St. Louis.

NAMED TO NEW POST

Edwin C. Walton (M.), who has been serving as Acting General Manager of The Kaman Aircraft Corporation, was named to the post of Vice-President and General Manager. During his 23-year association with aeronautics, Mr. Walton has been with Curtiss-Wright Corporation, War Production Board, Harriman Mission to London, American Airlines, and American Overseas Airlines. He is an Associate Fellow of The Royal Aeronautical Society.

Charles A. Fulton (T.M.), now Liaison Engineer, Purchasing Department, Sikorsky Aircraft Division, United Aircraft Corporation.

Charles J. Gallant (A.F.), Vice-President and General Manager, Columbus Division, North American Aviation, Inc. Formerly, Assistant to the President (in charge at Columbus since taken over by the company last December), North American Aviation.

Theodore R. Gensel (T.M.), Flight Test Engineer, Chase Aircraft Company, Inc. Formerly, Engineering Draftsman "B," Chase Aircraft.

Seymour Gottlieb (M.), Contract Administrator, Helicopter Division, Bell Aircraft Corporation. Formerly, Head, Flight Research, Naval Air Experimental Station, Philadelphia.

Vernon K. Gunkel (M.), Chief, Mechanical Engineering Section—GS12, Industrial Group, Engineering Branch, Ordnance Guided Missile Center, Redstone Arsenal, Ala. Formerly, Associate Professor of Engineering, Alabama Polytechnic Institute.

Charles L. Hall (A.F.), Technical Representative in Charge of Dayton (Ohio) Office, Bell Aircraft Corporation. Formerly, Chief Project Engineer, Fighter Branch, Engineering Division, Air Materiel Command, Wright-Patterson Air Force Base, Ohio.

Private Robert J. Harris, U.S.A. (T.M.), now Aeronautical Engineer, 9301 Training Service Unit, Ballistics Research Laboratories, Aberdeen Proving Ground, Md.

Herbert E. Jacques (T.M.), Production Engineer, Aircraft Engine Division, Ford Motor Company. Formerly, Service Representative, Ford.

Chester Keasling (M.), Sales Engineer, Pacific Division, Bendix Aviation Corporation. Formerly with Vanoni-Keasling Aircraft Company.

Gustav Kuerti (M.), Naval Ordnance Laboratory, White Oak, Silver Spring, Md. Formerly, Assistant Professor, Harvard University.

Alfred Lehrer (T.M.), Stress Analyst, Lockheed Aircraft Corporation. Formerly, Aeronautical Research Scientist, Structures Division, Langley Aeronautical Laboratory, N.A.C.A., Va.

John W. Miles (M.), Auckland University College, Auckland, New Zealand. Formerly, Associate Professor of Engineering, University of California at Los Angeles.

Eric Olsen (M.) Head, Special Projects, McClellan Air Force Base, Calif. Formerly, Engineering Photographer.

Courtland D. Perkins (M.), Chairman, Department of Aeronautical Engineering, Princeton University. Formerly, Professor, Department of Engineering, Princeton.

James R. Polski (T.M.), Graduate Student, Northwestern University. Formerly, Flight Test Engineer, Flight Test Planning Engineering Department, Chance Vought Aircraft Division, United Aircraft Corporation.

Donald K. Robertson (M.), Group Engineer—Vibration Analysis, The Glenn L. Martin Company. Formerly, Senior Vibration Analysis Engineer, Martin.

NEW POSITION AT MARQUARDT

Robert K. Wead (M.) has now become associated with Marquardt Aircraft Company as Assistant to the Chief Power Plant Engineer. Formerly with Consolidated Vultee Aircraft Corporation since 1943, he has been on the engineering staffs of the Miami, Fort Worth, Nashville, Vultee Field, and San Diego divisions. From 1945 on, he was working with the Bumblebee Project and was Convair's member on the Bumblebee Propulsion Panel. At the time of his resignation, he was Program Coordinator for Ramjet Development.

Thomas L. Schepke (T.M.), Aeronautical Engineer, Airplane Structures Branch, Engineering Division, Air Materiel Command, Wright-Patterson Air Force Base, Ohio. Formerly, Student.

NEW APPOINTMENT

Robert H. Wendt (A.F.), Vice-President, Globe Corporation's Aircraft Division, was recently appointed General Manager in charge of the Globe plants in Joliet, Ill., Williams Bay, Wis., and Oxnard, Calif. Mr. Wendt, who succeeds Russell E. Gage to this position, was formerly Vice-President of Engineering of the Aircraft Division at Globe.

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Captain E. A. Senkbeil, U.S.A.F. (T.M.), 343rd S. R. Sqdn., A.P.O. 845, c/o Postmaster, New York City. Formerly, Lieutenant, Barksdale Air Force Base, Ala.

Alvin C. Smith (M.), Aeronautical Research Engineer, Development Division, Cornell Aeronautical Laboratory, Inc. Formerly, Technical Power-Plant Unit Head, Airplane Division, Curtiss-Wright Corporation.

Floyd E. Snow (M.), General Manager, Aero-Cal Engineers, Inc. Formerly, Chief Engineer, Coast Paint and Chemical Company.

Robert E. Span (M.), Manager, Analytical Section, Westinghouse Electric Corporation. Formerly, Development Engineer and Group Leader, Westinghouse.

Ellis R. Spaulding (M.), Branch Head in Charge of Hangar and Instrumentation, Flight Research Department, Cornell Aeronautical Laboratory, Inc. Formerly, Staff Engineer, Revere Corporation of America.

W. F. Spurr (M.), Assistant Director, Research and Development Branch, Headquarters, British Ministry of Supply. Formerly, Chairman, Aircraft Branch, Technical Services, British Joint Services Mission, Washington, D.C.

G. F. Towner (M.), Manager, Turret Systems Section, Westinghouse Electric Corporation. Formerly, Supervisory Engineer, Special Products Development Division, Westinghouse.

J. Parker Van Zandt (F.), now Deputy Assistant Secretary of the Air Force, Department of the Air Force, Department of Defense, Washington, D.C.

Saul Wasserman (T.M.), Aeronautical Engineer GS-7, Naval Ordnance Laboratory, Md. Formerly, Aeronautical Engineer GS-5, N.A.C.A., Langley Air Force Base, Va.

Allen O. Whipple, Jr. (A.M.), Vice-President & General Manager, The Ivy Corporation. Formerly with Marquardt Aircraft Company.

Corporate Member News

• **Aeroproducts Division, General Motors Corporation** . . . The erection of the steel structure for the recently announced plant expansion program will begin about June 15; completion is planned by September 1.

• **Aeroquip Corporation** . . . All the outstanding stock of Metalco, Inc., has been purchased by Aeroquip. This newly acquired company will continue as a wholly owned subsidiary of Aeroquip.

• **Aircraft Gas Turbine Division, General Electric Company** . . . The Packard Motor Car Company has been selected to build the J-47 turbojet engine. According to an announcement, 14 months would be required for tooling, with an additional 10 months passing before peak production would be reached . . . L. T. Callahan was recently appointed Manager of Operations of this Division. In that capacity he is responsible for coordinating all divisional activities at Lynn and Everett, Mass.

• **Allison Division, General Motors Corporation** . . . The J35-A-23 jet engine is scheduled to go into production under the terms of a U.S.A.F. contract. This particular turbojet engine has a thrust rating said to be substantially higher than any jet heretofore produced and, in addition, offers a reduction in specific fuel consumption. The T40 series of turboprop engines is slated for production sometime in 1951; production facilities are now being established in Indianapolis.

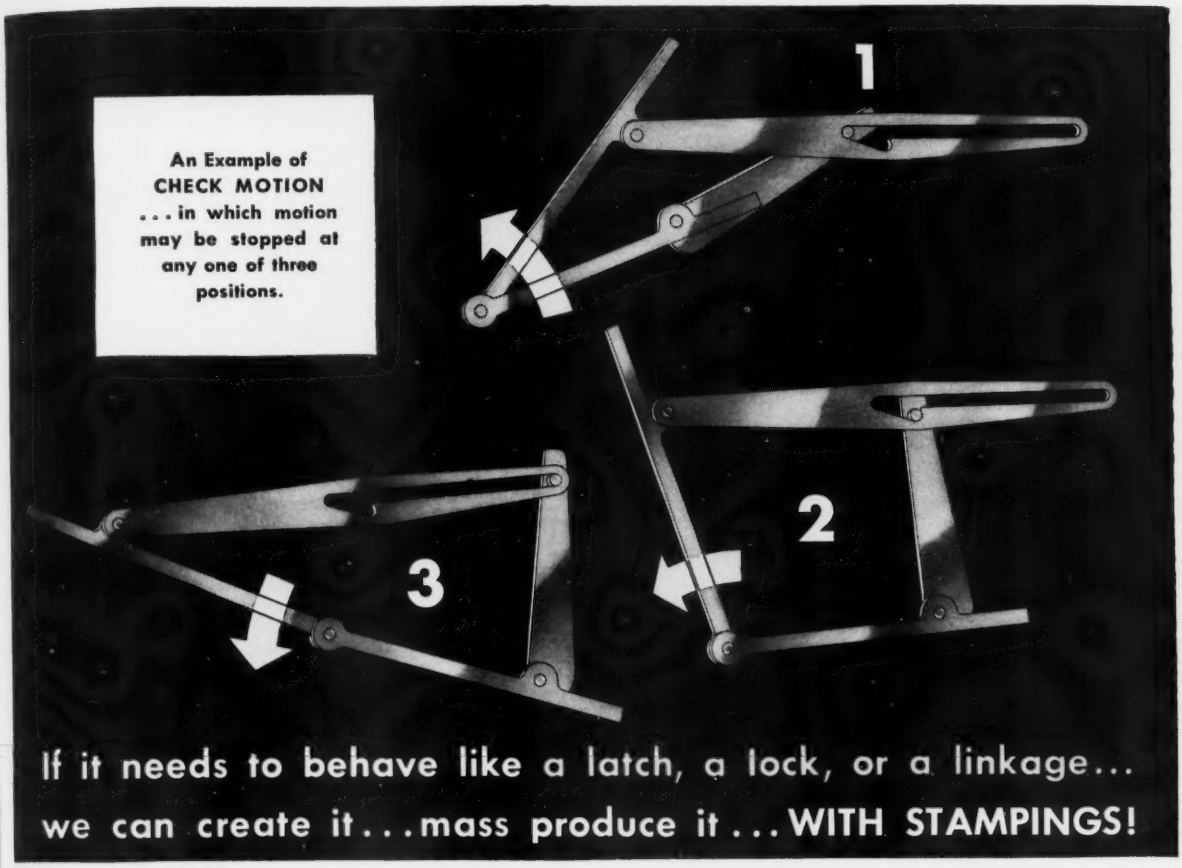
• **American Airlines System** . . . Three additional DC-6B four-engined transports have been ordered from Douglas Aircraft Company, Inc. This order raises to 17 the total number of the larger faster models of the 52-passenger DC-6 to be purchased by American. All 17 are scheduled to be delivered this year at a cost of about $19,000,000.

• **Bell Aircraft Corporation** . . . All administrative, engineering, contractual, sales, service, spare parts, and related functions of the Helicopter Division have been consolidated in a two-floor office building, containing 38,000 sq.ft., at Kenmore, N.Y. Until other arrangements are made, all helicopter production and testing work will continue at Bell's principal facility adjacent to the Niagara Falls airport . . . Of the 152,000 sq.ft. of the former Globe Aircraft facility at Fort Worth, Bell took possession of 130,000 sq.ft. last February 22. Bell has its eye on the remaining 22,000 sq.ft., as well as other property in the immediate area. The Globe facility will be used as a jet-engine nacelle build-up shop for the B-36 and B-47 bombers . . . A new research plane, designated the X-5, is said to be under development at Bell. According to reports, the X-5 is a high-speed, jet-propelled ship that features wings with a variable sweepback angle.

• **Boeing Airplane Company** . . . The Air Force has authorized the production of the eight-jet swept-wing B-52 heavy bomber. Two experimental models are now under construction in Seattle. The first of these XB-52's is expected to fly sometime this year . . . A portable, self-attaching, air-motor-driven device for countersinking holes in heavy-gage sheet metal is said to reduce by 80 per cent the time ordinarily required for this type of work and to cut man-hour costs by 90 per cent. Developed at Boeing primarily for the B-47 production program, this new auto-sink tool is apparently able to countersink a 1/2-in. hole in 75ST aluminum alloy in 30 to 40 sec. Application has been made for a patent on the tool; meanwhile, a contract has been signed with Buckeye Tools Corporation for their exclusive license to manufacture and sell the device . . . The first transport in a new series of Stratofreighters, the C-97C, was delivered to the U.S. Air Force on February 27 . . . All late-type B-50's now have as standard equipment aerial-refueling facilities for receiving fuel in the air from tankers using the Boeing-developed "Flying Boom"-type system. Earlier B-50's utilize the older

ANTISUBMARINE HELICOPTER

A small scale model of the Navy's XHSL-1, the first helicopter designed specifically for antisubmarine warfare, is shown above. Manufactured by Bell Aircraft Corporation, this tandem-rotored helicopter marks Bell's first departure from its familiar single-rotored helicopter configurations. However, basic Bell rotor-system principles are incorporated in the XHSL-1, particularly the rigid two-bladed rotors and patented automatic stabilizing device. The fore and aft rotors are interconnected, and power is supplied by a Pratt & Whitney R-2800 engine, in buried installation. The photograph of the model depicts how the rotors can be folded for elevator transportability aboard aircraft carrier or other type ship.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CHECK MOTION
. . . in which motion may be stopped at any one of three positions.
1
2
3
If it needs to behave like a latch, a lock, or a linkage...
we can create it . . . mass produce it . . . WITH STAMPINGS!

Perhaps your product requires a carefully-engineered motion device to enhance its safety . . . performance . . . salability.

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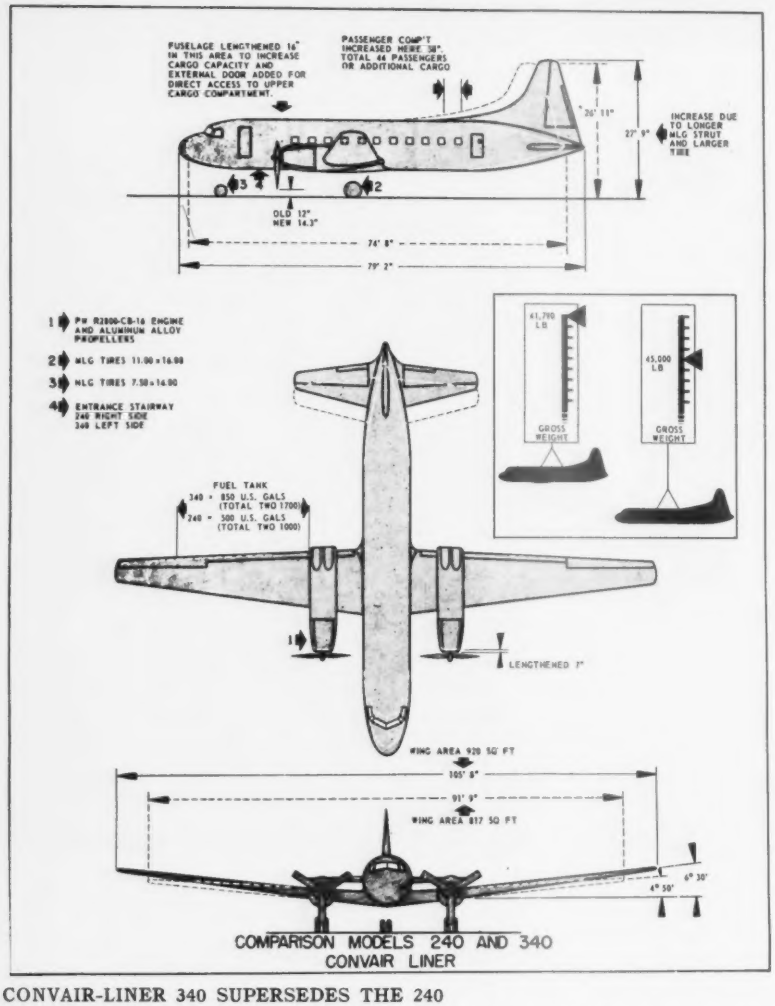
FUSELAGE LENGTHENED 16' IN THIS AREA TO INCREASE CARGO CAPACITY AND EXTERNAL DOOR ADDED FOR DIRECT ACCESS TO UPPER CARGO COMPARTMENT.
PASSENGER COMP'T INCREASED HERE 38". TOTAL 44 PASSENGERS OR ADDITIONAL CARGO
INCREASE DUE TO LONGER MLG STRUT AND LARGER TIRE
OLD 12" NEW 14.3"
74' 8"
79' 2"
1 PW R2800-CB-16 ENGINE AND ALUMINUM ALLOY PROPELLERS
2 MLG TIRES 11.00 x 16.00
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4 ENTRANCE STAIRWAY 240 RIGHT SIDE 340 LEFT SIDE
41,790 LB
45,000 LB
GROSS WEIGHT
FUEL TANK
340 - 850 U.S. GALS (TOTAL TWO 1700)
240 - 500 U.S. GALS (TOTAL TWO 1000)
LENGTHENED 7'
WING AREA 920 SQ FT
105' 8"
91' 9"
WING AREA 817 SQ FT
4° 50'
6° 30'
COMPARISON MODELS 240 AND 340
CONVAIR LINER

CONVAIR-LINER 340 SUPERSEDES THE 240

Consolidated Vultee Aircraft Corporation's new Convair-Liner 340 is based on the design of the earlier Model 240. The 340 will be powered initially with two 2,400-hp. Pratt & Whitney reciprocating engines; however, provisions are being made in the 340's design to accommodate turboprop engines, with the minimum of modification and expense, as soon as this type of engine is commercially available. Production of the new model began last January.

"hose and reel" system. The tanker aircraft designed to refuel the B-50's on long-range missions are modified B-29 Superfortresses designated KB-29P's by the U.S.A.F.

• **Consolidated Vultee Aircraft Corporation** . . . An integrated production plant for supersonic guided missiles was activated on March 1 as a new Convair division. The Missile Division, which began operations immediately, is currently occupying 200,000 sq.ft. of floor space. This unit is completely self-contained, with its own machine and other shops, industrial relations section, engineering department, and assembly facilities. The first production project involves a supersonic antiaircraft missile for the Navy's Bureau of Ordnance.

• **Douglas Aircraft Company, Inc.** . . . A new slide rule, tagged the "Sky Rule," has been developed at Douglas and will permit quick and easy computation of aircraft performance data. The Sky Rule has, in addition to the conventional "C," "D," and "A" scales, 20 others peculiar to aviation. Scale markings are theoretically accurate to 0.0001 in. According to claims, this slide rule makes it possible to determine at a glance the Mach Number, true air speed, indicated air speed, density altitude, temperature rise, and numerous other aeronautical functions. Performance may be evaluated in either miles per hour or knots. Douglas has granted the manufacturing and sales rights to Pickett & Eckel, Inc., Chicago . . . The Structural Test Laboratory, El Segundo Plant, Douglas, has been expanded into a new building that was especially built for testing modern high-speed carrier-based aircraft. This structure, 100 by 120 ft., will have a 40-ft. vertical clearance inside, thus permitting the drop-testing of even the largest carrier planes now contemplated.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation** . . . The first of a series of 2-week training courses was completed at Fairchild early in March by a supervisory group from Kaiser-Frazer Corporation. This training program is designed to acquaint Kaiser-Frazer personnel with all activities surrounding the manufacture of the Fairchild C-119 Packets and is being sponsored by the Aircraft Division under the assistance agreement between the two companies. Supervisors from the Aircraft Division are conducting the courses.

• **Fairchild Guided Missiles Division, Fairchild Engine and Airplane Corporation** . . . New facilities are under construction on a 32-acre site at Wyandanch, L.I., N.Y. The first unit to be built is a 155,000-sq.ft., one-story plant. The Guided Missiles Division, which is currently located at Farmingdale, L.I., will move into the new plant as soon as sections are completed; full operation at the new location is expected by September 1.

• **General Electric Company** . . . A testing system that can duplicate the complete electrical system of an airplane at speeds and loads equivalent to actual flight operation is currently in operation at Schenectady. Capable of testing normal loads, as well as short circuits and overvoltages, the test stands determine whether generators, distribution circuits, and control systems can operate satisfactorily under all generator speeds. The stands also test for overloads, conditions of reduced generation capacity, and any abnormal conditions such as failures or faults. These stands are currently being used for the development of the 28-volt d.c. systems for commercial and military aircraft, as well as the 400-cycle a.c. and 120-volt d.c. control systems.

• **The Goodyear Tire and Rubber Company** . . . A participating fellowship for study of the two-dimensional stress-strain properties of airship and mechanical goods-type fabrics has been established at the Textile Research Institute, Princeton, N.J. The donation amounts to $5,000 per year for a 2-year period.

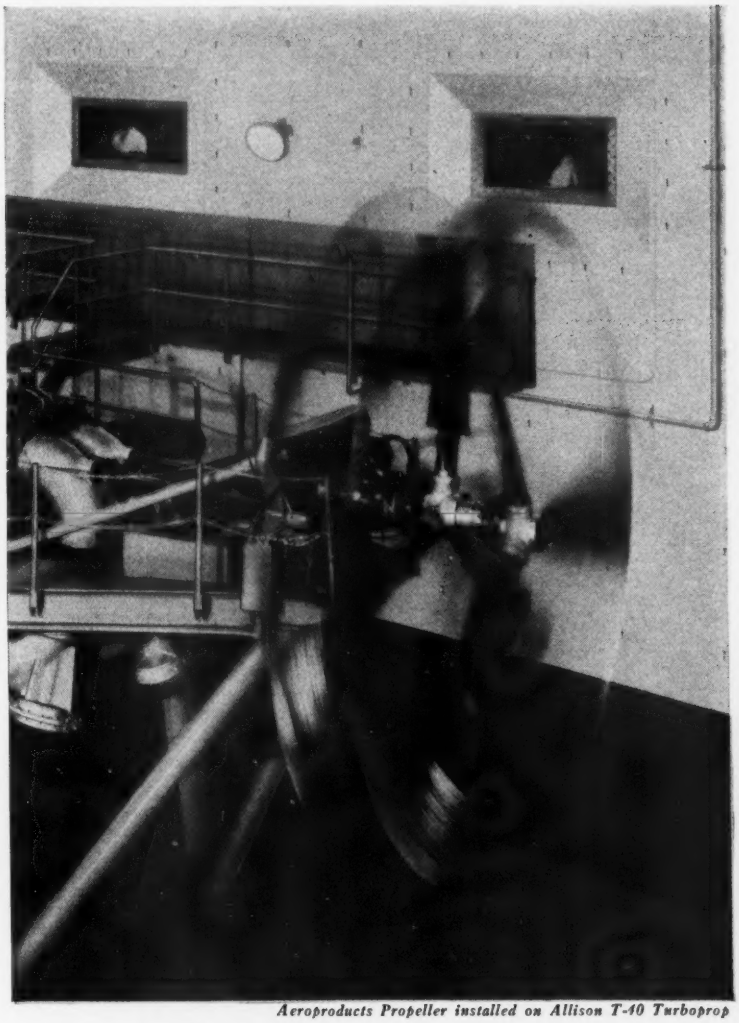
• **Walter Kidde & Company, Inc.** . . . A new self-contained fire-fighting crash truck, called the "Kidde Fire Destroyer," has been designed for airport fire emergencies and for municipal fire departments with particular emphasis on civil defense fire-fighting problems. The truck has built-in systems that deliver water, foam, fog, and carbon dioxide; it can dispense 2 tons of combined extinguishing agents per minute. Classified as a Class A municipal pumper, the Fire Destroyer has a heavy-duty chassis and is powered with a 162-hp. motor, which permits speeds up to 50 m.p.h.

• **Lockheed Aircraft Corporation** . . . The fabrication and assembly of major components of the Lockheed T-33 jet trainer and F-94 all-weather fighter has been subcontracted to Rheem Manufacturing Company's Aircraft Division. The subassemblies to be manufactured by Rheem include complete nose sections of the F-94 and the T-33. The work will be under the direction of Laurance H. Cooper, A.M.I.A.S.

• **The Glenn L. Martin Company** . . . Present plans call for the production of the British Canberra light jet bomber in this country at Martin under license from the English Electric Company, Ltd., Rugby, England. A model of this night-intruder

First to harness dynamic turboprop power!

Aeroprop



Aeroproducts Propeller installed on Allison T-40 Turboprop

A new day has dawned in the history of flight—the day of turboprop power!

For the dynamic combination of turboprop engines and Aeroprops opens up a great and new era when cargo ships, bombers and fighters will fly at near- or super-sonic speeds.

And they'll fly with range and performance that until now have been only a dream—a dream brought to life on the drawing boards of the men at Aeroproducts.

Aeroproducts, working in close contact with the Navy and Air Force, has pioneered propeller design for turboprop power . . . has, by its research and never-ending experimental work, blazed the trail of propeller driven supersonic speed for all others to follow.

December, 1945—a dramatic milestone in the development of turboprop power! For it was then that the Convair F-81 was flown, first Air Force fighter using turboprop power. And from these tests came knowledge for the development of Aeroprops for new planes that utilize the full power, the enormous thrust of the turboprop engine and Aeroprop combination—and set wonderful new standards of aircraft performance.

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GENERAL MOTORS CORPORATION
DAYTON, OHIO

GM GENERAL MOTORS

Building for today
Designing for tomorrow

AEROPRODUCTS GM

Aeroproducts

TAILLESS NAVY JET FIGHTER

The XF4D-1, designed and built by the El Segundo Division, Douglas Aircraft Company, Inc., was successfully flown for the first time on January 23 at Edwards Air Force Base, Calif. This jet interceptor was designed for catapult take-off from carriers and rapid climb to the upper atmosphere.

version of the twin-jet high-speed aircraft was flown to Martin for a detailed study to speed up preproduction planning. The Canberra (R.A.F. designation B.2), now being built in the United Kingdom for the Royal Air Force, is powered by two Rolls-Royce Avon engines, each of which delivers over 6,000 lbs. of thrust . . . Eastern Air Lines' latest order for an additional 25 of the Martin 4-0-4 air liner brings to 60 the total number of this type ship ordered by Eastern since March, 1950. Deliveries on the initial order are expected to start within the next few months; the recent order of 25 is scheduled to begin delivery in April of next year and cover a 4-month period. This latest purchase brings the number of 4-0-4's on order at Martin to an even 100, including the 40 ordered by Trans World Airlines in the spring of 1950.

• **Meletron Corporation** . . . Thomson Engineering Service, Fort Worth, has been appointed distributor for Meletron's pressure-actuated switches and related products.

• **Minneapolis-Honeywell Regulator Company** . . . Automatic pilots, electronic fuel-gage systems, and gyroscopes will be turned out by the new $1,500,000 aero plant now under construction. This building is the third to be provided for expanding aeronautical operations within the last 1½ years . . . The engineering personnel and departmental facilities of the Valve Division have been expanded by 400 per cent, according to an announcement last February.

• **North American Aviation, Inc.** . . . Expanding activities have led to the leasing of over 273,000 sq.ft. of additional space in six outside facilities. This space will be utilized for manufacturing, engineering, flight test, and other activities . . . The recently created Electro-Mechanical Division is engaged in the design, development, and manufacture of electronic equipment and complete guidance control systems for missiles and aircraft produced at North American and other companies.

• **Northrop Aircraft, Inc.** . . . "Iron Ike," a completely authentic mock-up of the hydraulic systems used in the F-89's, has been credited with saving many months and man-hours in the developmental process of the F-89's full-power control system. Its construction on a structural steel network gives "Iron Ike" that name. With the test stand, engineers are able to reproduce the action of control surfaces under varying flight conditions. "Iron Ike" has a control cockpit similar to that of an airplane and is fully instrumented for simultaneous recording of pressures, control positions, control timing, and fluid temperatures.

• **Pan American World Airways, Inc.** . . . Special Sleeperette seating equipment for the 18 DC-6B-type clippers ordered from Douglas Aircraft Company, Inc., has been purchased. The seats, each stressed for 16g, were designed to P.A.A. engineering specifications by The Thermix Corporation and are to be manufactured by Aerotherm Corporation. The installation of these seats on tracks will make it possible to convert the seating capacity of the DC-6B's in a few hours for deluxe Sleeperette, standard, or low-cost tourist flights.

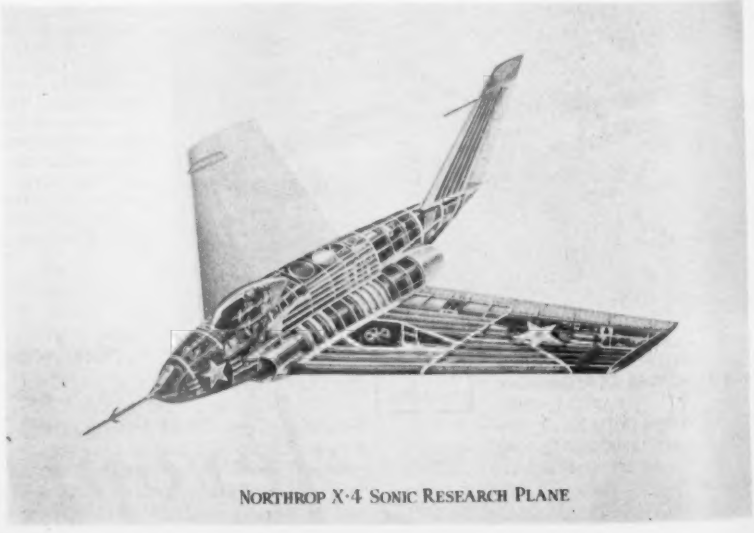
• **Piasecki Helicopter Corporation** . . . An extension to the Morton plant is nearing completion and, when finished, will add approximately 200,000 sq.ft. of floor space to the original area. This, plus leased areas, will give Piasecki well over 500,000 sq.ft. of space by the end of 1951.

• **Republic Aviation Corporation** . . . The Sapphire turbojet engine, which develops 7,200 lbs. of thrust, will be installed in the production models of the Republic F-84F Thunderjet. The American version of the Sapphire is to be manufactured by the

(*Continued on page 76*)

HIGH SUBSONIC EXPLORATORY SHIP

Revealed for the first time in this phantom drawing are the internal details of the U.S.A.F.'s X-4 research airplane, manufactured by Northrop Aircraft, Inc. Space reserved for the pilot is reduced to a minimum in order to provide room for more equipment and instruments, including N.A.C.A. stability and control instruments. Integral fuel tanks are built into the multicellular wing panels. Northrop elevons in the trailing edge of the wing provide both aileron and elevator control. The X-4, which has approximately a 25-ft. wing span and a 20-ft. overall length, is not intended to be a supersonic plane. Conversely, it was built to explore flight conditions in the high subsonic speeds.



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More savings for you. We have the facilities and the special equipment that means production for you on schedule—in any volume.

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BTU/HR 100,000 200,000 300,000 400,000

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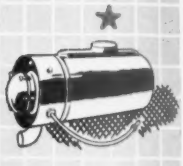
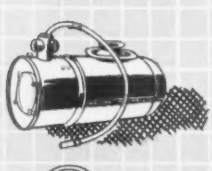
USAF Type A-1 Ground Heater, *

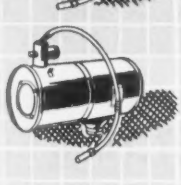


940 SERIES
200,000 BTU/HR
Boeing B-47, B-50, C-97 ★



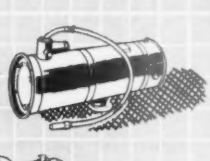
377 "Stratocruiser"

921 SERIES
200,000 BTU/HR
North American P-82, * ★



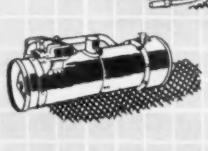
Boeing B-50; Beech 51; Grumman UF
Lockheed P2V; Martin 202, P4M, P5M;

930 SERIES
100,000 BTU/HR
★



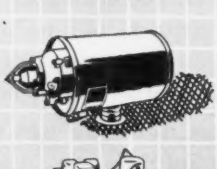
Boeing B-29, B-50; Martin P4M; North American AJ-1

906 SERIES
50,000 BTU/HR
★



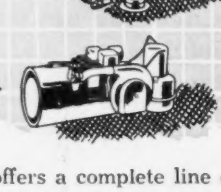
Consolidated PBY; Grumman TBF; Martin PBM, P5M;
North American B-25, PBJ; Bell H 12, *

960 SERIES
25,000 BTU/HR
★



Boeing B-29, B-50; Douglas ADQ; Grumman F6F;
North American P-82, *

970 SERIES
20,000 BTU/HR
★



Beech 50; Bell H-13; Cessna 170, 190; Ryan "Navion";
Sikorsky H03S—Power Pack Preheating

*New application not released from military censorship.

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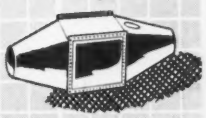
South Wind

your aircraft heating problem!

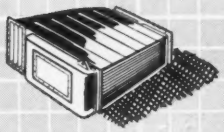
BTU/HR 100,000 200,000 300,000 400,000

800,000

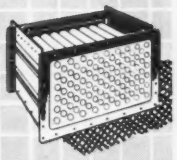
MODEL 68077-AA
800,000 BTU/HR
Northrop B-35 ★



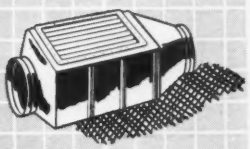
MODEL 68141
450,000 BTU/HR
Curtiss-Wright P-87 ★



MODEL 923
380,000 BTU/HR
Northrop F-15 ★

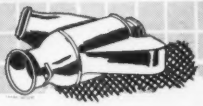


MODEL 918
345,000 BTU/HR
Fairchild C-82 ★



MODEL 910
240,000 BTU/HR
Consolidated B-36 ★

MODEL 912
160,000 BTU/HR
Consolidated PB4Y, B-24 ★



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INERT GAS GENERATORS

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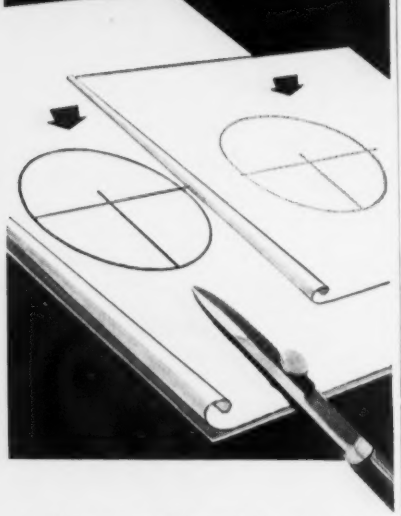
THAT DEFIES TIME!



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(*Continued from page 72*)

Curtiss-Wright Corporation under license agreement with British designers, Armstrong Siddeley Motors, Ltd. No delivery date for the first production units has been announced.

• **Servomechanisms, Inc.** . . . The SA-203 Amplifier, now in production for industrial use, is a compact, plug-in unit containing the electronic circuits for the control of a 60-cycle, two-phase servomotor of a 5-watt mechanical power output (Diehl FPE 25-11 or equivalent). The SA-203 measures only 5 in. in width by 8 in. in length by 4 3/8 in. in height; it weighs only 5 1/2 lbs.

• **Solar Aircraft Company** . . . A 60-acre tract located near Solar's Des Moines (Iowa) plant has been purchased. When the construction of the new 300,000-sq.ft. plant is completed on this acreage and the facilities at the San Diego main plant are expanded per schedule, Solar will have a total plant area of about 1,100,000 sq.ft.

• **Stratos Division, Fairchild Engine and Airplane Corporation** . . . The C.A.A. has approved a 2,000-hour service period for the Stratos Model S60-5A cabin superchargers installed in Pan American World Airways' Constellations.

• **United Air Lines, Inc.** . . . The first of 20 DC-6B's on order from Douglas Aircraft Company, Inc., was delivered on March 2 to United. This air liner will carry 58 passengers, a crew of five, and 6,000 lbs. of cargo . . . A contract has been signed with Consolidated Vultee Aircraft Corporation for the purchase of 30 new-type Convair-Liners, Model 340 (see picture, page 70). It is said that the new fleet will cost about $16,500,000 and that first deliveries are to be made early in 1952.

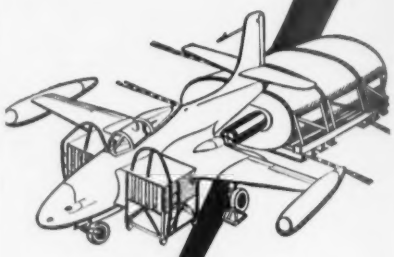
• **Westinghouse Electric Corporation** . . . The headquarters plant and engineering laboratories of the new Electronic Tube Division will be located on a 100-acre tract 4 miles northwest of Elmira, N.Y. Completion of construction work is scheduled for the early part of next fall.

• **Wright Aeronautical Corporation, Curtiss-Wright Corporation** . . . The American version of the Sapphire is to be installed in the production models of Republic Aviation Corporation's F-84F, according to a recent announcement. The Sapphire, produced here under a long-term engineering and production agreement with Armstrong Siddeley Motors, Ltd., of England, carries the U.S.A.F. designation, J-65. It is also known as the Wright Typhoon J-65. No delivery date for the first production units of the Sapphire-powered F-84F has been announced.

• **Young Radiator Company** . . . Certain selected types of heat-transfer products are now being manufactured in Canada under special license arrangements granted James B. Carter, Ltd., it was announced. Carter has been given manufacturing privileges to certain of the Young designs and engineering specifications and will produce heat-transfer units exclusively for the Canadian market, thus providing a substantial saving to Canadian customers in transport costs, etc.

INDUSTRIAL SOUND CONTROL
Quiets Noise...
OF
JET AND RECIPROCATING
ENGINE TEST CELLS

PUT AN END TO . . .
ANNOYANCE, COMPLAINTS,
THREATS OF LEGAL ACTION



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U.S. Royalite can be punched, sewed, sanded, cemented, polished, sheared, drilled or sawed. Royalite can be formed into simple or complex shapes and is produced in almost any color, in a smooth or grained finish.

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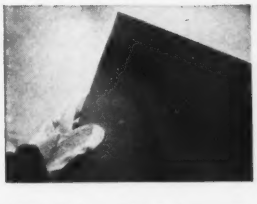
A blow torch that develops tremendous heat is directed on a square of flame-resistant U. S. Royalite.



After being subjected to this intense heat, flame-resistant U. S. Royalite has *not* sustained combustion.

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STANDARD OR FLAME RESISTANT

UNITED STATES RUBBER COMPANY

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Meet Your Section Chairmen

William R. Hawthorne

Boston Section

William Rede Hawthorne made his first professional appearance in the aeronautical sciences shortly after the outbreak of World War II while he was associated with the Royal Aircraft Establishment. Prior to this time, he had been employed by a Scottish firm of boiler makers, Babcock & Wilcox, first as a student engineer and later as an engineer and divisional head. In this last capacity, he was in charge of the development of forced-circulation boilers.

During his connection with the Royal Aircraft Establishment from 1940 to 1944, Mr. Hawthorne experienced two of today's outstanding memories. The first was the occasion of the initial flight in 1941 of the E28/39, the first British experimental turbojet aircraft. The other was investigating the German buzz-bomb both before and immediately after its appearance over England. His work at the Establishment was intimately concerned with the research and development of gas-turbine aero-engines. In the early phases of the war, he was sent to work with Sir Frank Whittle on the combustion problems of the turbojet engine and its development.

In 1945, Mr. Hawthorne became associated with the British Air Commission in Washington, D.C., in a technical liaison position in which he was concerned with jet-propulsion development. He left this in 1945 to become Deputy Director in the Ministry of Supply and was placed in charge of aircraft-engine research. The following year, he accepted an associate professorship at the Massachusetts Institute of Technology. Two years later, he was made a full professor, and he currently occupies the chair of the George Westinghouse Professor of Mechanical Engineering. In addition to his teaching the usual courses in thermodynamics, etc., he also conducts research in fluid flow.

William Hawthorne was born on May 22, 1913, in Newcastle-on-Tyne, England, and attended England's Trinity College, from which he was graduated in 1934 with a B.A. degree. From 1934 to 1937, he took postgraduate work at M.I.T., and in 1939 he received his D.Sc. degree from this college.

Mr. Hawthorne has had many papers published in various scientific journals, such as the *Journal of the Institute of Fuels*, *Journal of Applied Mechanics*, and the JOURNAL OF THE AERONAUTICAL SCIENCES.

He now lives in Belmont, Mass., with his wife, his 11-year-old son, and his two daughters, ages 5 and 2. Sailing, fishing, and hiking are his forms of relaxation.

George F. Towner

Pittsburgh Section

George Ford Towner was graduated from Clarkson College of Technology with a B.S. degree in Mechanical Engineering in 1933, right in the middle of the depression employment difficulties. Openings for a newly graduated engineer were obviously at a premium, but suppose Mr. Towner tells the story in his own words. "After 4 depression years of selling brushes and playing the bull fiddle in Northern New York pubs, I finally landed a job in September, 1937, with Kellett Autogiro in Philadelphia. I worked on the YG-1B's, made a preliminary design on a one-man 'flying motorcycle,' and engineered a crop-duster conversion of a Pitcairn 'giro for the Department of Agriculture. Moved over to Hall-Aluminum at Bristol in the old Keystone plant in November, 1938, and worked on the PH-3 (where I broke into armament work) until September, 1939, when I went with Martin in Baltimore. Started in the B-26 armament group, worked on bomb bays and gun mounts, and laid out the deck turret. Made Armament Group Engineer in November, 1940, and transferred to the newly organized Turret Group on its formation in 1941. Grew with the group through Assistant Project Engineer, Design Engineer, to Assistant Chief of Design Section. Quit in August, 1948, to go on my own, couldn't swing it financially, and landed with Westinghouse."

Mr. Towner is now Manager of the Turret Systems Section, Special Products Development Division, Westinghouse Electric Corporation. In this regard he says: "In spite of the awkward title, my duties would be described as a Project Engineer in an aircraft company. I initiate and supervise development and production design on all turret systems we have under contract and try to meet schedules. I also act as an ex-officio mechanical consultant to the Division. My major job is to correlate the activities of a group of radar, servo, and turret specialists to arrive at an integrated design."

How come George Towner chose aeronautics rather than some other branch of engineering? "In high school," he writes, "I first considered aeronautical engineering as a profession—probably because of the fascination left over from my model-making days. During the depression, the first engineering job offered me was in aircraft, and I have stuck to it."

In speaking of what might be considered the most interesting episode of his career, Mr. Towner relates: "The most gratifying incident was when, after designing the B-26 turret (never having seen one before), we put it in an airplane and took it out to Eglin Field for air test firing. It worked! So we built 55,000 before the war was over."

Mr. Towner was born in Saranac Lake, N.Y., on March 28, 1911. He attended the local public school system through high school and then went on to Clarkson. He has taken graduate work (without credit) in aeronautical engineering, electronics, plastics, and industrial management. He has had 2 hours of dual instruction on a J-3 Cub airplane.

There have been two patents issued to Mr. Towner so far. The first of these covers a bomb-control unit; the second is for an aircraft machine-gun turret. Various other patents for which he has applied are currently pending.

He was married on December 31, 1935 to Thelma E. Dudley. He calls himself an "enthusiastic volunteer fireman" and loves "music from Dixie to Dvorak."

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I.A.S. Sections

Baltimore Section

M. Francis Taylor, *Secretary*

A joint meeting of the local A.S.M.E. and I.A.S. groups was held at the Engineer's Club on January 22. Frank N. Piasecki, Chairman of the Board of Directors, Piasecki Helicopter Corporation, and pioneer of the tandem-rotor helicopter, was speaker of the evening.

Samuel B. Sexton, III, Chairman of the Baltimore A.S.M.E. chapter, presided over the combined dinner meeting. After the dinner, the General Motors' film, *The Diesel Engine*, was shown in which the development of the compression-ignition type power was traced. The film stressed the precision accuracy requirements of the fuel-injection-system components and ended with a display of the variety of applications to which diesel power has been adapted.

Mr. Piasecki's address was entitled "The Military Aspects of Transport Helicopters." Well illustrated by both color movies and slides, the lecture covered a comprehensive survey of the types of service, versatility, and possibilities of the helicopter at war. Reference was also made to a comparative cost economy of the helicopter as a transport vehicle, as well as to its peacetime uses.

A number of interesting tactical warfare situations were presented by Mr. Piasecki to demonstrate the utility, economy, and often indispensability of the helicopter. Largely through its unique ability to hover over any particular ground location, the helicopter is well suited to transporting heavy items of field-artillery equipment to the desired spot where land transport over rough terrain is cumbersome. Again, the combined operations of transporting fresh assault troops to the front line and the evacuation of wounded can be performed in one round trip, with the bonus of administering lifesaving blood transfusions en route as required.

Numerous other missions can be performed by the helicopter, according to Mr. Piasecki. At sea, the helicopter performs air-sea rescues more efficiently and economically than the destroyer heretofore used and, at the same time, frees the destroyer to perform its function. Over land, it has been used to rescue wounded G.I.'s behind enemy lines and to replace even the jeep for improved mobility. Vulnerability to enemy fire is less than might be supposed, since vital sections of the rotor blades, the power plant, and the transmission shafting present small projected area targets.

Once large transport helicopters are available in quantity, the need for specially qualified, highly trained paratroopers is eliminated and replaced by regular infantry assault troops, carried to their initial destination by helicopter.

In terms of defense, the transport helicopter plays an important role. This vehicle can serve as an aerial radar-defense station, perform decontamination operations against germ warfare, and evacuate civilian populations afflicted in A-bomb areas.

Mr. Piasecki pointed out that the helicopter as a transport vehicle competes readily with other forms of transportation when the huge construction and maintenance costs of concrete highways, railroad beds, and airports are considered.

Boston Section

L. J. Nuttall, *Secretary*

Northeast Airlines, Inc., played host to the members of the Boston Section on February 21 for a discussion on "Airline Maintenance" and for a tour through the maintenance facilities at Logan Airport.

To start the evening, Mr. McKinnen, Supervisor of Maintenance, Northeast, presented an excellent talk on maintenance requirements, methods, and practices. Besides explaining the routine maintenance procedures, Mr. McKinnen told of some of the unique problems they had run up against and how they had solved them. He also stressed the emphasis the air lines place on safety in all their operations. The talk was followed by a discussion period where the questions of the group were answered.

A tour of the facilities followed, starting in the instrument laboratory where checking, calibrating, and overhauling of all instruments used in their planes is done. From there, the group was shown through the main hangar where the work on the complete airplane, with the exception of the power plant, is carried on. Here, it was pointed out just how much attention various parts of the airplane receive and also some of the methods used for doing various checks and repair jobs. The tour wound up in the engine overhaul plant where a step-by-step analysis of the overhaul procedure was given. The engine test stands were also examined.

This meeting was enlightening and was well received by those present. It is now easy to understand why the Northeast Airlines, Inc., has such an enviable safety record.

Buffalo Section

Hans Weichsel, Jr., *Secretary*

Robert E. Fulton, Jr., President, Continental, Inc., spoke on "Airphibian, the Roadable Airplane" at the December 11 meeting held at the Colvin Casino. By giving a résumé of many of his previous experiences, Mr. Fulton was able to show how the Airphibian came about. He also gave the various requirements that had to be met by the "roadable airplane" and described its performance. Mr. Fulton was an excellent speaker and was well received by the Section.

▶ The January 31 meeting was held jointly with the American Helicopter Society, at the Westbrook Hotel, with a turnout of over 60 persons, including guests. The speaker, C. R. Woods, of McDonnell Aircraft Corporation, was introduced by A. Price. Mr. Woods spoke on "Little Henry—The Ram-Jet Helicopter." He gave a brief description of the design, including construction details, performance, and weight values. The problem of blade selection and rotor diameter were mentioned, and the advantages of the ram-jet were clearly presented (its low maintenance, low initial cost, ease of flying, simplicity, and great lifting capacity). A short discussion of the advantages and disadvantages of ram- and pulse-jets for helicopter applications was included. The talk was summarized by listing the many advantages of a ram-jet helicopter such as "Little Henry" and by forecasting a tremendous potential for the ram-jet helicopter both for military and civilian use.

▶ A dinner meeting was held on February 21 at the Westbrook Hotel. The speaker of the evening was introduced by R. Frost after a brief business session that covered the activities of the Civil Defense and the responsibilities of the technical societies in relation to Civil Defense. The speaker, Gene Halperin, Aviation Section, Special Devices Center, Office of Naval Research, spoke on "A Man-Machine Approach to Cockpit Problems." The talk was illustrated with numerous slides showing the various methods of presenting data to the pilot. The importance of the instrument-face design was pointed out. Several different methods of presenting flight attitude to the pilot were covered. A lively discussion followed, with Test Pilot and Engineer R. Stanley presenting some interesting aspects from the pilot's point of view concerning "stick intelligence" (i.e., stick feel).

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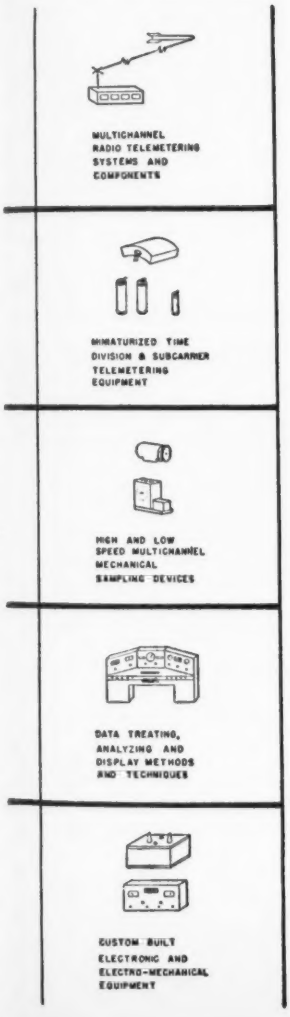
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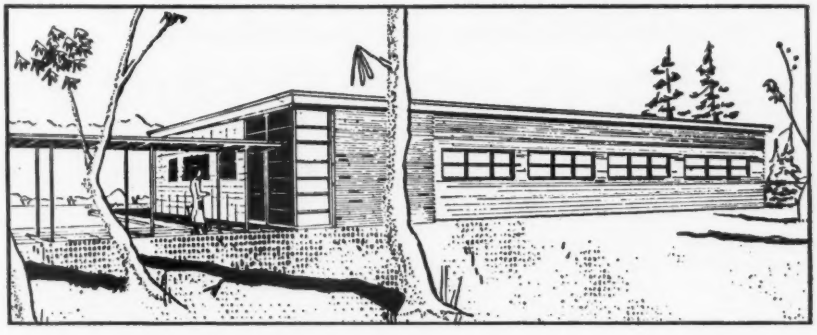

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Chicago Section

Alfred Stott, *Secretary*

One of the most interesting and educational meetings was held on February 20 at the Argonne National Laboratory.

One hundred and fifteen members and guests attended a fine cafeteria dinner at the Laboratory at 6:00 p.m. At 8:00 p.m., the group had grown to 150, and Section Chairman K. L. Burroughs called the meeting to order and introduced Dr. H. L. Hull, Director, Remote Control Engineering, Argonne Laboratory. Dr. Hull in turn introduced Dr. W. H. Zinn, Director, Argonne National Laboratory, who welcomed the members and guests.

Dr. Hull, who was the principal speaker of the evening, gave a brief description of the work done at the various Atomic Energy Commission establishments and particularly at the Argonne Laboratory. A fine description of problems encountered in handling "hot" materials (radioactive) by remote control was given. Movies were shown illustrating the use of remote-control devices, such as mechanical hands and fingers, for performing experiments in adjacent rooms. The high light of the program was a demonstration of the three-dimensional television equipment that enables the operator to perform experiments a great distance from his position by controlling the mechanical hands electronically and watching the results on his television screen. Those present were allowed to try their hands at the remote-control devices. It is hoped that this type of equipment may be used in the future to conduct experiments many miles away from the operator.

Ray Brittan, Project Engineer, Reactor Division, Argonne Laboratory, and a member of the Chicago Section, presented two fine movies and commented on each. One was *The Tale of Two Cities*, showing the effects of the bombing of Nagasaki and Hiroshima; the other was *Operation Crossroads*, a colored picture that showed the testing of the Atomic Bomb at Bikini.

A rousing vote of appreciation was given to Dr. Hull, Ray Brittan, and the Laboratory personnel who arranged the program and made the visit possible. Chairman Burroughs closed the meeting at 9:45 p.m.

Hagerstown Section

Robert A. Darby, *Secretary*

A dinner meeting was held on February 20, attended by 31 members and their guests. Robert D. Gilson, Chairman, presided. Speaker of the evening was Capt. Robert A. Lavender, U.S.N. (Ret.), prominent Washington, D.C., patent attorney and patent consultant to Fairchild Engine and Airplane Corporation. The speaker was introduced by H. J. Sieradzki, Chairman of the Program Committee.

Captain Lavender presented a comprehensive survey of the patent system as it exists in the United States and discussed the troublesome question of what does and what does not constitute invention. He traced the history of patent law from the provision in the Constitution, "the Congress shall have power. . .to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries," through the major revisions of the laws in 1836 and down to the present. The various steps in securing a patent, from the conception of the invention through the issuance of the patent by the Patent Office, were discussed, and many interesting examples were cited to show the right procedure and common mistakes. One step of particular importance is the disclosure in which the inventor, as consideration for his patent rights, explains his invention to the public. The sketch or drawings comprising the disclosure should carry the wording, "disclosed to and understood

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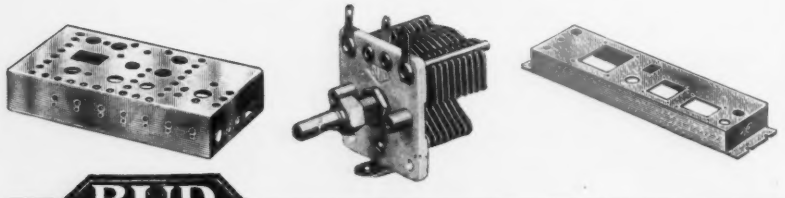

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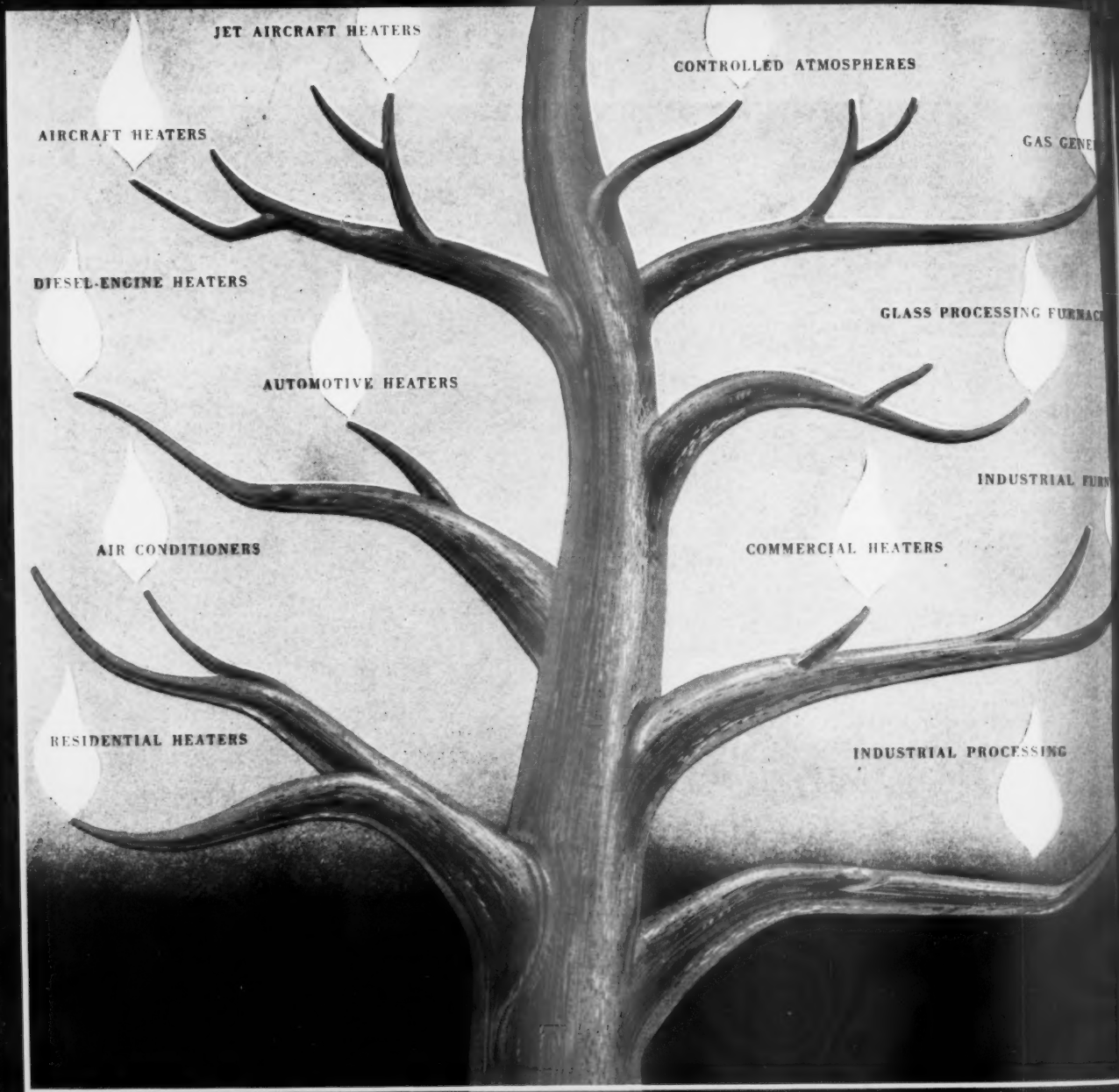
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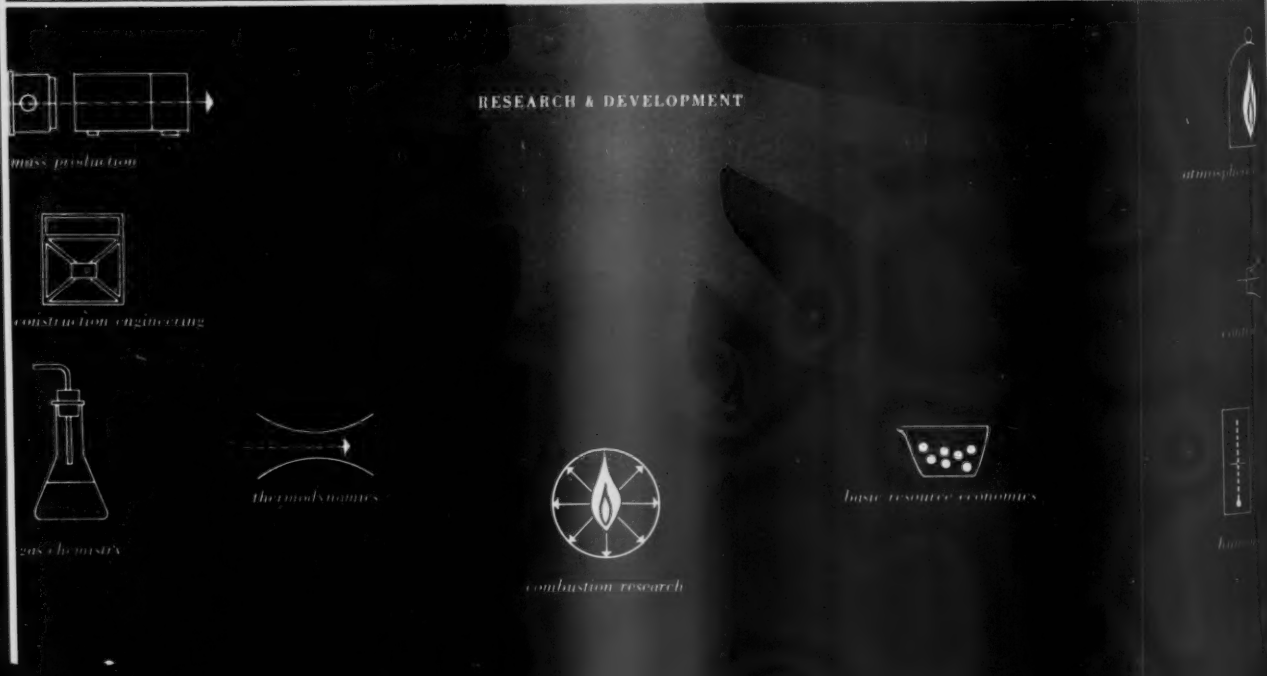
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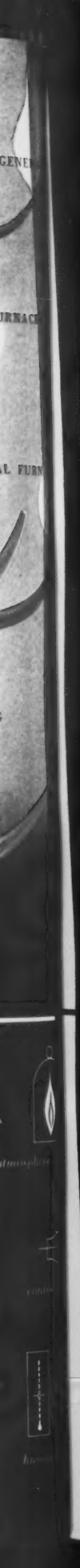

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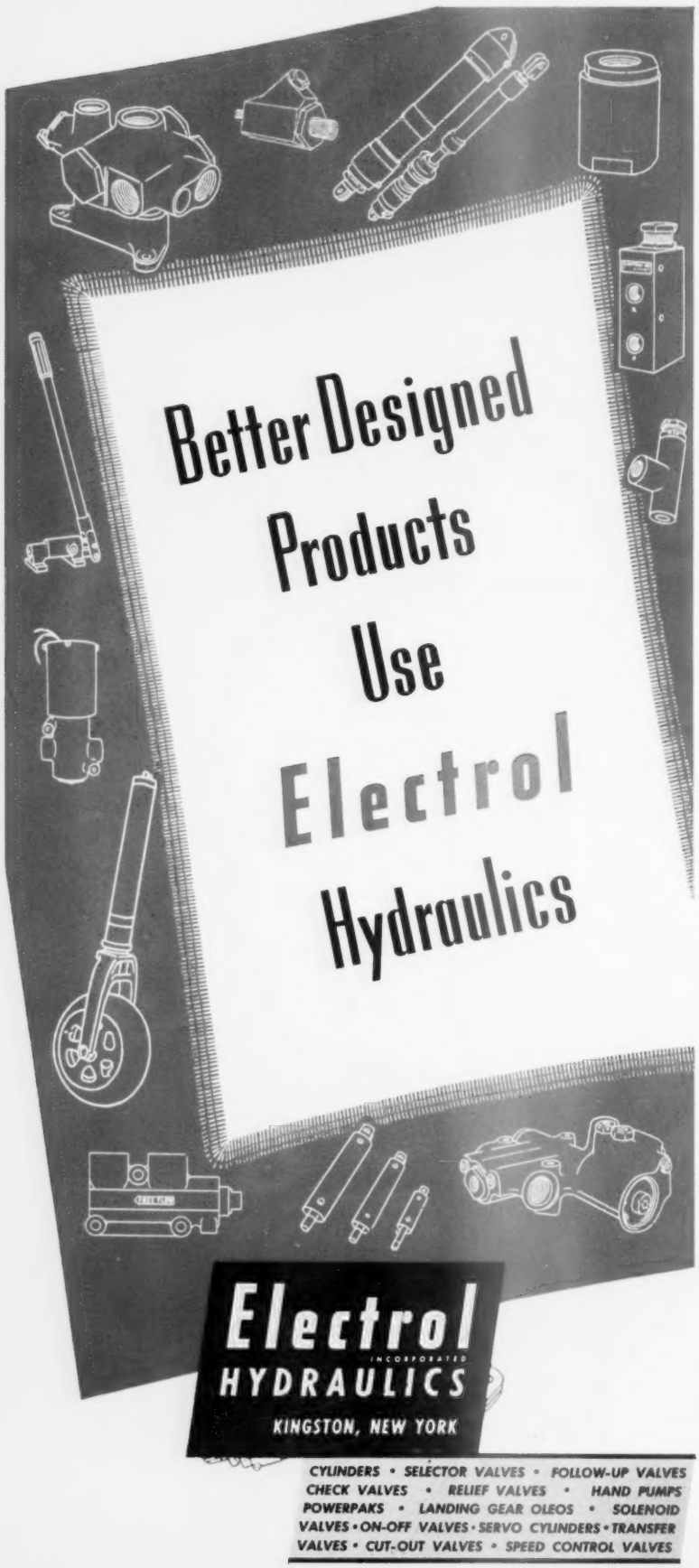

by," and the signers should by all means be people whom a court would deem capable of understanding the invention. The inventor should be careful in explaining his invention and should be sure that the witnesses can give a creditable explanation. After discussion of claims and infringements, the speaker answered numerous questions from the floor.

At this meeting H. C. Billings of the Program Committee announced that three cash prizes have been offered by the Fairchild Aircraft Division for the best papers on aeronautics to be presented this year by anyone in the Hagerstown area. It was also announced that E. E. Morton would replace B. A. Lindner as Area Nominating Committee Representative and that Robert A. Darby would take the place of J. O. Gibson as Secretary-Treasurer, these men having moved from the Hagerstown vicinity.

Hampton Roads Section

George White, *Secretary*

Members at the February 19 meeting had the pleasure of hearing Comdr. Thomas F. Connolly, Director, Flight Test Pilot School, Naval Air Test Center, Patuxent River, Md. The subject of his talk was "Requirements and Acceptance Tests for Naval Aircraft." The speaker was introduced by Melvin N. Gough, Chief, Flight Research Division, Langley Aeronautical Laboratory, N.A.C.A.

Flight characteristics of several of the latest types of service aircraft were discussed by Commander Connolly as he pointed out their desirable features and their shortcomings. He emphasized the urgent need for an all-out effort in aeronautical-research activities as a primary factor in maintaining our Nation's supremacy in the air.

An interesting film was shown, illustrating some of the newest Naval aircraft performing catapult take-offs and arrested landings. During the showing, comments were made by the speaker, pointing out design features of the various types.

Following the presentation of his address, Commander Connolly engaged in an informal question-and-answer session, drawing upon his broad experience in Naval aviation to give comprehensive and sometimes humorous replies to the many questions put forth by the Section members.

Los Angeles Section

Milton A. Miner, *Secretary*

On January 10, J. M. Wild, Chief, Propulsion Wind Tunnel, ARO, Inc., talked before a specialists' meeting on

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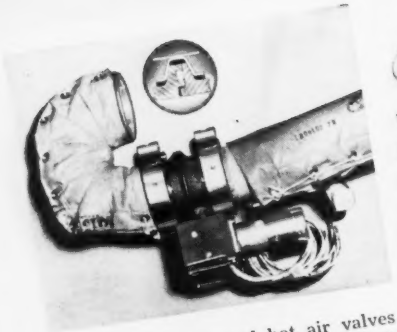

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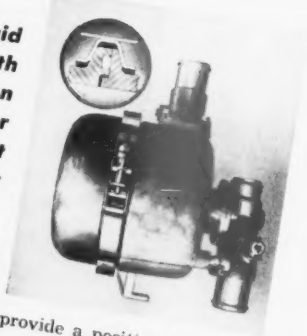

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the subject, "The Arnold Engineering Development Center—Stepping Stone to Air Power."

A general description was given, illustrated with slides, of the Air Force's new Arnold Engineering Development Center at Tullahoma, Tenn., with particular emphasis on the three major technical facilities now under construction. The relationship of the activities at this Center to the development program of industry and the mode of operation of the Center were discussed.

▶ A joint dinner meeting with the A.S.M.E. was held on January 18. The topic of the evening, "High-Speed Flight," was presented in its various aspects by the following: "Turbojet Engine Design for High-Speed Flight," Wesley V. Hurley, Air Design Specialist, Aircraft Gas Turbine Division, General Electric Company; "Turbojet Engines for Supersonic Flight," Arnold H. Redding, Section Engineer, Flow Research Section, Aviation Gas Turbine Division, Westinghouse Electric Corporation; and "High-Speed Aerodynamic Problems of Turbojet Installations," Harold Luskin, Aerodynamics Research Engineer, and Harold Klein, Aerodynamics Engineer, Douglas Aircraft Company, Inc.

This is a repeat performance by the original authors of the panel of papers first delivered at the annual A.S.M.E. meeting in New York on November 28. Although chiefly devoted to power-plant problems, these papers were of general interest, since each of these power-plant problems influences the general configuration of the aircraft.

Mr. Hurley discussed the basic design of the optimum engine for specific flight missions as affected not only by high flight speed, but high flight altitude.

In Mr. Redding's paper, the differences between a turbojet engine designed for subsonic flight and one primarily intended for supersonic flight were presented. These differences were examined component by component in order to give a better understanding of the problems of supersonic flight with a turbojet engine.

The paper jointly prepared by Messrs. Luskin and Klein covered the possibility of supersonic flight in turbojet-powered aircraft and the resulting thrust requirements from the point of view of the aerodynamicist. Inlet-pressure recovery and drag, the matching of inlet size to the engine, and the effect of exit and cooling losses were featured.

Montreal Section

G. E. Otter, *Secretary*

The March 1 meeting was held in the International Aviation Building. T. B. Rhines, Chief Development Engi-

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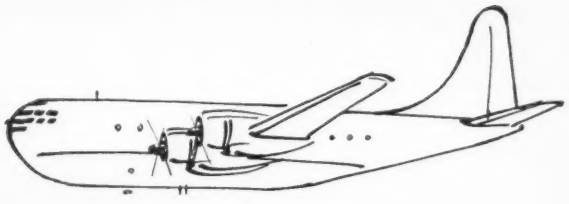

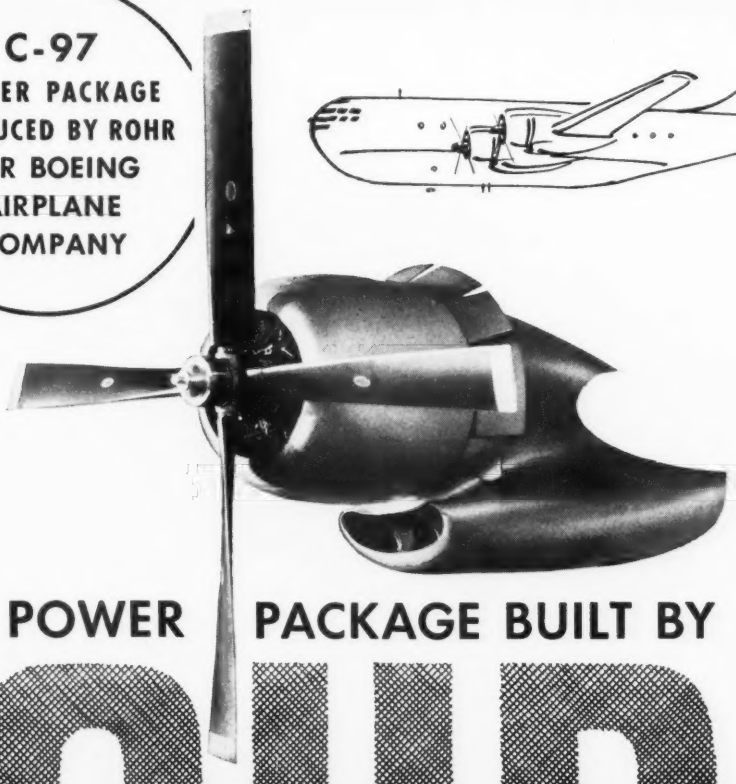

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neer, Hamilton Standard Division, United Aircraft Corporation, addressed the meeting on the subject, "New Horizons for a Propeller Manufacturer." Mr. Rhines has been associated with United Aircraft and Hamilton Standard since 1932 and has been intimately connected with propellers and propeller problems since that time. In his present position, Mr. Rhines is responsible for the design and developments of propeller hubs and control work, as well as new developments in air-conditioning equipment, pneumatic accessories, and jet-engine fuel controls.

Mr. Rhines assured the meeting that the propeller was not yet dead and that he was certain that propellers would have an active life as long as he was interested in airplanes. Recent studies have revealed a better understanding of the roles of the various propulsion methods. This more intelligent assessment of the limitations of each of the methods is in direct contrast with the earlier swing to the elimination of the propeller in future aircraft in favor of the new turbojet form of propulsion. It is now recognized that the propeller is destined to play an important part in the overall picture.

Recent trends in propeller designs have included new control mechanisms that would provide a propeller and control system for new engines without increasing the complexity of the design. Mr. Rhines mentioned that the skills and knowledge developed over a period of years in the propeller industry have been applied to the new fields of jet-engine fuel controls. The ruggedness and maintenance simplicity of the electronic control units were found to be of interest. He concluded with a brief outline of the Hamilton Standard refrigerating unit. An interesting discussion period followed.

Ottawa Aeronautical Society

J. C. Finlayson, *Ex-Secretary*

Jerome Lederer, Director, Flight Safety Foundation, Inc., spoke at the November 15 meeting on "Some Current Problems in Aviation Safety." He gave a most interesting presentation, commencing with a short discussion on the selection of suitable yardsticks for measuring safety. He then discussed the various aspects of service testing of prototype transport aircraft; accidents and their effects on air transport with particular reference to the sundry classes of financial loss involved; and some phases of fire both in flight and following a crash. He concluded his address with comments on the place of human factors in preventing accidents. The talk was illustrated by a number of slides and ended with the showing of an American Airlines training film, *This Way Out*. The meeting was held in the Auditorium of the National Research Council on Sussex Street. Approximately 45 members were present.

▶ The December 12 meeting had Squadron Leader J. G. Wright, D.F.C., as the speaker; his topic was "Research and Development in R.C.A.F. Navigation Instruments." Squadron Leader Wright gave a most interesting description of the problems involved in navigating in the polar region and showed that the normal navigation instruments are only of limited use in this part of the world. He then proceeded to describe the development of instruments specifically designed to make the task of polar navigation easier and also talked briefly on modifications to maps which had been found necessary. This meeting was held in the National Research Council's Auditorium. Approximately 40 members were present.

▶ On January 22, M. S. Kuhring, M.B.E., spoke to approximately 30 members on "Some Icing Studies of Gas Turbine Engines." Mr. Kuhring gave a most informative talk on the various aspects of the subject, opening with a discussion of the fundamental characteristics of turbine-engine icing, including investigation of water-droplet size and development of apparatus for producing a spray of supercooled water which duplicated the natural conditions as closely as possible. He outlined the several methods that can be used for anti-icing and deicing systems on several different types of gas-turbine engines, including turbojets and turboprops. This meeting was also held in the National Research Council's Auditorium.

▶ The February 15 meeting was held in the auditorium of the National Research Council. Approximately 45 members were present. Air Marshal G. O. Johnson was in the chair and announced that the first item of business was the annual elections for an executive for the 1950–1951 season. Nominations were called for, and the following slate of officers was duly elected by acclamation: Chairman, Dr. D. C. MacPhail, National Research Council; Secretary-Treasurer, T. E. Stephenson, National Research Council; I.A.S. Representative, Squadron Leader James N. Brough, R.C.A.F.; Engineering Institute of Canada Representative, J. C. Finlayson, Air Transport Board.

Wing Commander C. B. Limbrick was then introduced by Air Marshal Johnson, who continued in the chair because of the unavoidable absence of Dr. MacPhail. Wing Commander Limbrick delivered a most interesting paper on "Guided Missiles," commencing with a brief history of early efforts. He then reviewed the requirements that had to be met by guided missiles and discussed the functions of the various components of a missile in meeting the requirements. Different types of air frames were described, and the principal features of each of the several kinds of power plants available were explained. An outline was given of several types of guidance systems, and the paper ended with some possible peacetime applications of this type of vehicle. Some of the uses mentioned were carriage of mail, distribution of medical supplies and serums, and application of insecticides and other agricultural chemicals over large areas in a short space of time.

Air Marshal Johnson tendered a vote of thanks to the speaker on behalf of the Society.

St. Louis Section

Jack A. Durand, *Secretary*

The January 23 meeting was held at the Engineers' Club with Chairman Berlin presiding. Fifty members attended. Lapel badges, distributed to members as they entered the meeting, were used for identification so that the members might become better acquainted with one another. At the close of the meeting, the badges were collected to give a count of members present.

Mr. Harmon introduced Carl J. Wenzinger, who gave the talk for the evening. Mr. Wenzinger has held positions with the N.A.C.A. and the U.S. Navy's Bureau of Aeronautics; he worked with Consolidated in Texas and with Fairchild in Hagerstown. In 1949, he came to Sverdrup and Parcel, Inc., of St. Louis, where he is now serving as Head of Aerodynamics.

Mr. Wenzinger presented a most informative talk about the Arnold Engineering Development Center of Tullahoma, Tenn., and illustrated his subject with color slides of the existing and proposed facilities of this new testing center. Mr. Wenzinger stated that the 81st Congress in 1949 passed the bill authorizing the construction of the Development Center as a joint Air Force, Navy, C.A.A., N.A.C.A., university, and aircraft-company project. The Center, when completed, will cover 33,000 acres and will be comparable (as far as power, water, and other utilities are concerned) to a city of about 200,000 population.

The first operation is the Engine Test Facility in which the test section is six to eight times larger than any now existing at Wright Field; 75,000 hp. will be required for operation of the tunnel that will simulate a wide range of pressure, temperature, and altitude conditions. A Ram-Jet Facility will be an auxiliary to the Engine Test Facility

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Signal-Communication-Power in the AIRCRAFT INDUSTRY

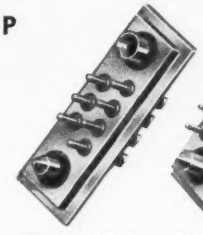
Hermetically Sealed

HM 14 P

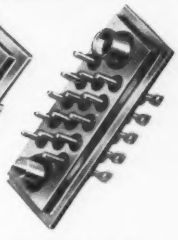
HM 7 P

Each contact separately sealed in glass.

(Illustrated actual size)



HMRE 7 P

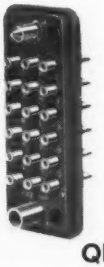


HMRE 14 P

Quick Disconnect

Patent No. 2,466,370

QRE 18 S



QRE 18 P

Each contact separately spring loaded.

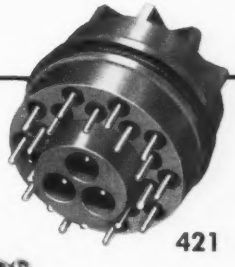
(Illustrated one-half actual size)

Pressure Tight

Patent No. 2,513,080

450

451



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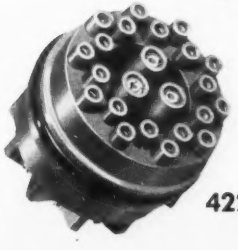

422

(Illustrated one-half actual size)

Each contact and insert has individual Neoprene ring.

WRITE FOR DETAILS:

We can help you with your more difficult connector problems.

Winchester Electronics

INCORPORATED

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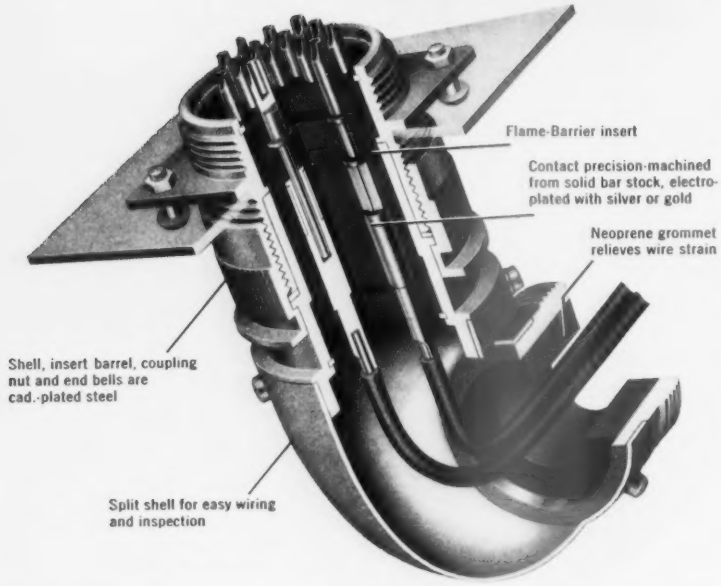
Here's why those in the know

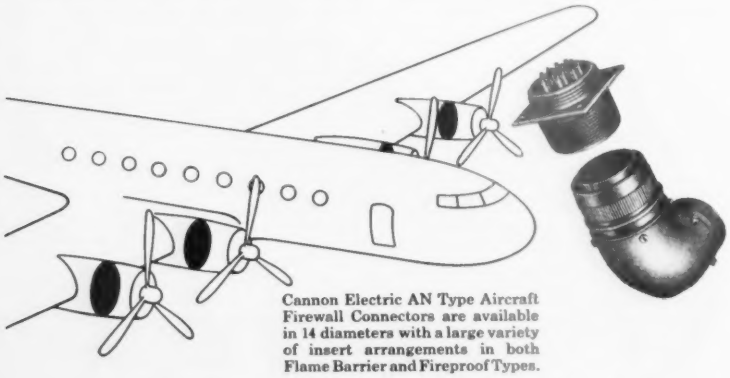
—demand **CANNON PLUGS**


Flame-Barrier insert
Contact precision-machined from solid bar stock, electro-plated with silver or gold
Neoprene grommet relieves wire strain
Shell, insert barrel, coupling nut and end bells are cad.-plated steel
Split shell for easy wiring and inspection

Here is another example of the care Cannon Electric takes in developing a connector for specialized use. This is the Firewall Connector to prevent the spread of a possible aircraft engine fire through the bulkhead into wing sections.

Illustration shows Flame Barrier type with phenolic insert and contacts having solder cups. Shell must resist an open flame of 2000° F for 20 minutes. Electric circuits not required to remain active.

The Fireproof continuous service type is similar in appearance, but has crimp-on type contacts in fireproof insert material. Must carry rated DC current under open flame of 2000° F for five minutes and withstand vibration of ¼" double amplitude at 2000 cycles per minute. Designed for aircraft, this connector has other applications where the going is tough. *For further information request Cannon Electric Firewall Bulletin.*



Cannon Electric AN Type Aircraft Firewall Connectors are available in 14 diameters with a large variety of insert arrangements in both Flame Barrier and Fireproof Types.

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The second is the Gas Dynamics Facility in which tests at supersonic and hypersonic speeds can be made (Mach = 1.2 to 5) over a wide range of the Reynolds Number. The third facility is the Propulsion Wind Tunnel; 200,000 hp. will be required to operate this tunnel, in which full-scale high-speed craft and installations in a speed range from high subsonic to supersonic can be tested. A range of altitudes from sea level to 70,000 ft. can be simulated. About 100,000 gal. of water per min. will be used for cooling purposes when the tunnel is operating at top speed.

San Diego Section

W. H. Shutts, *Secretary*

A dinner meeting was held on February 1 at the Park Manor Hotel. About 66 members and guests were in attendance to hear a talk by W. S Ivan, noted sailplane expert.

Mr. Ivan's talk was concerned primarily with various aspects of "standing-wave" soaring and with the details of his recent flight on which he established a new world's altitude record for sailplanes of 42,300 ft. Lantern slides and motion pictures were shown to point up certain phases of the discussion.

The principle of the standing wave is something analogous to the waves that may be noted at a distance downstream from an obstruction in a brook. Mr. Ivan stated that favorable conditions exist for this standing wave on the eastern or leeward side of the Sierra Nevada Mountains in central California.

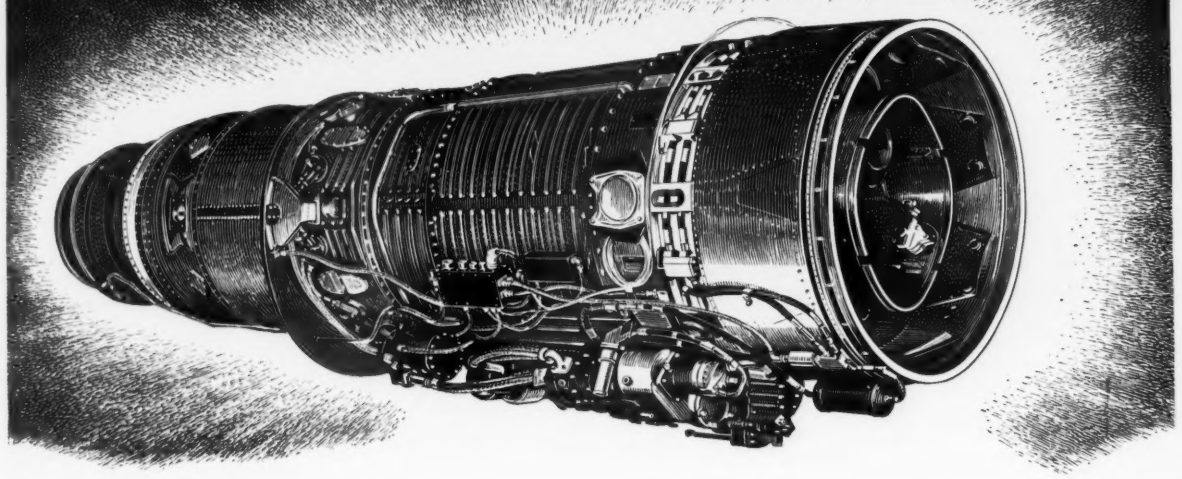
Meteorological phenomena associated with this wave include two types of clouds: the "roll" and the "lenticular." Both of these cloud types form at the crest of the wave and may be roughly airfoil-shaped. Thus, by flying near the leading or upstream edge of these clouds, the sailplane may take advantage of the strong updrafts in this area to gain considerable altitude.

Several excellent movie shots illustrated the method in which roll clouds are formed. These movies were taken at the Bishop (Calif.) Airport at the rate of 16 frames per sec., so that changes could be readily noted.

Roll clouds are being constantly built up on the leading edge and are being dissipated on the trailing edge so that they maintain a constant position relative to the terrain even though the local wind velocities at the roll-cloud altitude may be greater than 100 m.p.h.

One of the most extraordinary demonstrations of the strength the updrafts may attain in front of these standing waves was noted when a P-38 airplane soared for a period of more than 2 hours with both propellers feathered

Allison Wins Record U.S. Air Force Contract for Super-Jet Engines



New Turbo-Jet Leads with Greatly Increased Power and Fuel Economy

ONCE more Allison makes a major contribution to America's air power—a new Super-Jet aircraft engine that excels in power and fuel economy any other jet engine ever released for production.

It's the new J35-A-23 developed in cooperation with the Air Materiel Command—a completely new design—yet retaining the same basic diameter of the famed J35 series. This new engine develops more power per square foot of frontal area than any other jet yet produced. Four of these new engines will be installed in the YB-47C Boeing Strato-Jet. They will produce more power than the six jet engines now used in previous models of the B-47 series.

This J35-A-23 now has been selected by the Air Force—in open competition—for a record-size production contract. Behind this latest award is Allison's unequaled experience in the design and production of more than 10,000 jet engines with total time in the air of over 700,000 hours.

This accents the length and breadth of Allison jet engine experience where it counts most—in the air. Many of these flight hours have been accumulated in Korea powering U. S. fighters for support of ground troops and keeping the skies clear of enemy opposition.

Production will continue at Allison on those combat-proved types of jet engines in addition to the new J35-A-23 Super-Jet and the new T40 Turbo-Prop engines.

The record production order for the new Allison engineered Super-Jet will be met through the combined facilities of Allison and the Chevrolet Motor Division which will build a substantial quantity of these Super-Jets.

GM
GENERAL MOTORS

Builders of J35 Axial, J33 Centrifugal Flow Turbine Engines and T40 Turbo-Prop Engines

Allison
DIVISION GENERAL MOTORS CORPORATION
INDIANAPOLIS, INDIANA

"DEFENSE IS EVERYBODY'S BUSINESS—AIR POWER IS EVERYBODY'S PROTECTION"

during an unusually strong wind condition.

Texas Section

Roland Christy, *Secretary*

The February 21 meeting was held at the American Legion Hall, Grand Prairie. Approximately 200 members and guests were present to hear the lecture given by Robert C. Donovan, the guest speaker.

Mr. Donovan, Chief of Design, Chance Vought Aircraft Division, United Aircraft Corporation (formerly Project Engineer, Douglas Aircraft Company, Inc.), chose as his subject the "Design and Development of the Douglas Skystreak and Skyrocket." Through the courtesy of Douglas, his lecture was supplemented by slides and motion pictures.

Mr. Donovan explained how Douglas entered into a contract with the Navy and worked with the N.A.C.A. to design and build six experimental research airplanes. There were many configurations studied to establish the one to be built—being designated the Skystreak. The development, design features, and testing of it were explained. This research program was later split into Phase I and Phase II, with the second phase being the design of the Skyrocket. Again, he pointed out in detail the arrangement and construction features and discussed the methods of handling the special and highly explosive fuels used. The trailer truck used for servicing and transporting the airplanes at Edwards Air Force Base was of unique design. Mr. Donovan concluded his talk by showing motion pictures of the construction and testing of these distinctive airplanes.

Wichita Section

Melvin H. Snyder, *Secretary*

The March 1 dinner meeting was held at Droll's English Grill, with Chairman Douglas C. Heimburger presiding. Thirty persons attended.

After the dinner, the meeting was opened with a short talk by George Baughman, Staff Engineer, Cessna Aircraft Company. Mr. Baughman is the I.A.S. delegate to the Wichita Council of Technical Societies and is one of the editors of the *Wichita Tech News*. He reported that the Council of Technical Societies and other professional groups have joined together to organize the civilian defense program of Wichita. They plan to investigate all of the utilities and to make arrangements for help to, or operation of, the various facilities in the event of emergency. He solicited help and criticism from the members.

The main speaker of the evening was M. J. Gordon, Chief, Aerodynamics Group, Beech Aircraft Corporation. Mr. Gordon spoke on the "Performance Development of the Beech Mentor." The Mentor is widely known as the Model 45 trainer. Mr. Gordon stated that the objective of the design of this plane was to produce a trainer for the armed services comparable to the A-6 in training potential but with less horsepower and a lower gross weight.

The first of these planes to be built was composed of a Bonanza power unit complete with cowling, Bonanza wing panels, and an empennage consisting of three Bonanza tail-surface units. To the original configuration was added a Continental 225-hp. engine equipped with exhaust-jet augmentors. The structure was "beefed-up" for an ultimate load factor of 10. Larger fuel tanks were installed in the wings, and considerable reworking was done on the empennage. The final gross weight is 2,700 lbs. The airplane has been certified by the C.A.A. in the acrobatic category. To date, three Mentors have been built.

Mr. Gordon supplemented his talk with slides showing the various configurations as the plane progressed to its final form. He also showed a movie of the Mentor performing acrobatics.

Student Branches

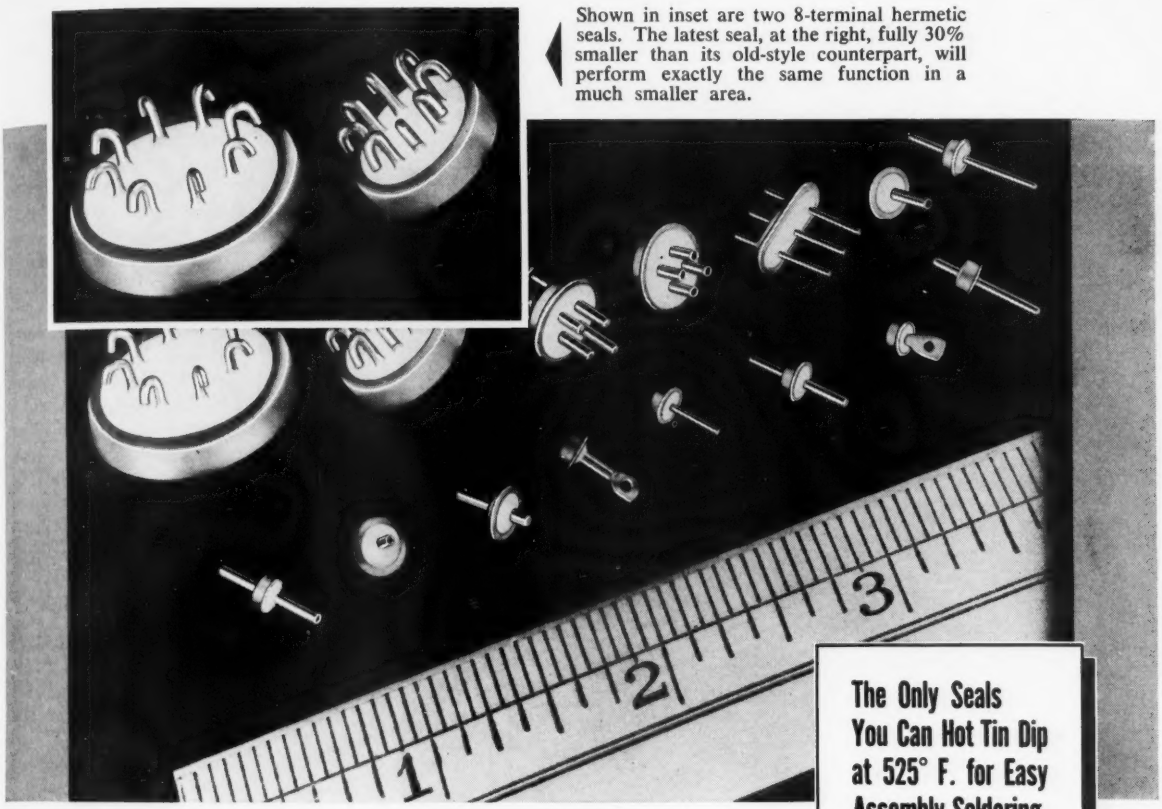
California State Polytechnic College

Twenty-seven members and guests attended the January 9 meeting at which Student Members T. M. Epperson and Charles A. Johnson (Corresponding Secretary) spoke on "Dissipation of Waste Heat in Radial Engines" and on "Shock Wave Theory in High-Speed Flight." A film, *N.A.C.A. Research Laboratories*, was shown. Chairman Milo V. Price presided.

On January 23, Student Members Milo V. Price (Chairman) and Clinton Sherbourne (Vice-Chairman) presented talks on "Metal Bonding" and "The Big Cane." Two films, *Aircraft Production Processes—Manufacturing Methods* and *Aircraft Production Processes—*

SOUTHERN CALIFORNIA'S I.A.S. STUDENT BRANCHES MEET

A joint meeting of the I.A.S. Student Branches in Southern California was held on December 1 at the Institute's Western Headquarters in Los Angeles. Shown in the accompanying photo are the representatives of the four schools concerned, the I.A.S. Western Manager, and the speaker of the evening. From left to right are: James C. Spriggs, Vice-Chairman, Cal-Aero Technical Institute; Theodore R. Metz, Chairman, University of Southern California; Ed M. Owen, Chief, Flight Operations, Northrop Aircraft, Inc., and speaker of the evening; Ernest W. Robischon, I.A.S. Western Manager; H. Dana Moran, Chairman, Northrop Aeronautical Institute; and Howard Shavdal, representing California Institute of Technology's Student Branch. Messrs. Metz and Moran, who have since been graduated, presided jointly at the combined meeting. Mr. Owen's address covered the topic "Service Testing and Evaluation of Military Aircraft."



Shown in inset are two 8-terminal hermetic seals. The latest seal, at the right, fully 30% smaller than its old-style counterpart, will perform exactly the same function in a much smaller area.

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The Only Seals You Can Hot Tin Dip at 525° F. for Easy Assembly Soldering, for a Strain and Fissure-Free Sealed Part with Resistance of over 10,000 Megohms!

Just a Few of Hermetic's Amazing NEW Line of MINIATURE Glass-Metal Headers

Today's industrial and military production calls for myriad components and controls. The size of each part must, therefore, be kept to a minimum. As a result Hermetic, with its unequalled specialized experience in hermetic seals, has developed and engineered a superb, thoroughly practical line of glass-metal headers in the smallest sizes ever made.

These components have already passed stringent tests, are being used successfully and are ready to go to work for you, too. Available in unlimited shapes, they are unaffected by extremely high or low temperatures, high humidities, vacuums, high operating pressures, swamp test, salt water immersion and spray, etc. They can be produced surprisingly economically in large or small quantities, thus giving you every opportunity to determine how well these headers can perform with your own products.

IMPORTANT: Terminals and Headers are Available in RMA Color Code.

Free! Write for your copy of the most complete catalog ever produced on hermetic seals.

SEALED IN HERMETIC HEADERS

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THE HEADER SEAL GUARANTEED IMPERVIOUS TO EVERY ELEMENT!

NEW F-86 JET IS LEDEX EQUIPPED!

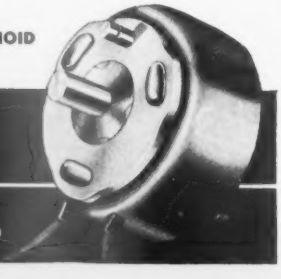
NORTH AMERICAN AVIATION Chose LEDEX *ROTARY* SOLENOIDS *for DEPENDABILITY!*

Humid tropics, sand-laden desert skies, frozen North or extremely high altitudes . . . the new Air Force North American F-86A Sabre Jet Fighter is prepared to defend our nation under *any* conditions. Ledex *Rotary* Solenoids play an important part in this *dependability*. Several vital mechanisms are remotely controlled and powered by Ledex *Rotary* Solenoids.

The same Ledex standard of dependable remote control and power is available for your product. The vast production applications of Ledex *Rotary* Solenoids vary from the dependable snap-action operation of aircraft mechanisms to the powerful actuation of rugged hydraulic valves in heavy duty materials handling equipment.

We supply to quantity users and solicit the opportunity to be of assistance in engineering a Ledex *Rotary* Solenoid to meet the requirements of your product.

Write today for LEDEX *ROTARY* SOLENOID BASIC ENGINEERING DATA



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Mock-up and Tooling, were screened. Chairman Price presided; 33 members and guests were present.

Chairman Price opened the February 13 meeting at which Student Members Richard Campbell and H. A. Bellows spoke on "Lear L-2 Automatic Pilot" and "Firing Procedure for the V-2 Rocket." *Sailors with Wings*, *RAF in Action*, and *Curiosity Shop* were the films shown to the 27 attending members. Chairman Price presided.

On February 27, 27 members heard Student Member Felicito I. Majarucon speak on "Ceramic Turbine Blades." This was followed by Edward Rogers, Instructor, Economics Department, Cal Poly, who presented a lecture on "What an Employer Looks for in an Applicant." Two films, *PBM-3 Wing Destruction Test* and *Cyclone Combustion*, completed the meeting. Chairman Price presided.

The Catholic University of America

On February 21, Samuel Levy, Stress Engineer, National Bureau of Standards, presented a lecture on "Stresses on Aircraft Structure." After the talk, a film, *Free Turning Wind Tunnel*, was shown to the 24 attending persons. Chairman Charles J. Carney presided.

University of Cincinnati

On February 19, Student Members Oscar Dillon, Jr., and Odin R. Elnan were awarded the two annual Ferdinand L. Weston Memorial Prizes as the outstanding senior aeronautical engineering students. Professor Bradley Jones, Head, Department of Aeronautical Engineering, made the presentations. A talk was also given on this occasion by G. Arleigh Dom, a former student at Cincinnati now working at The Glenn L. Martin Company. His subject was "Some Aspects of Aerodynamic Design."

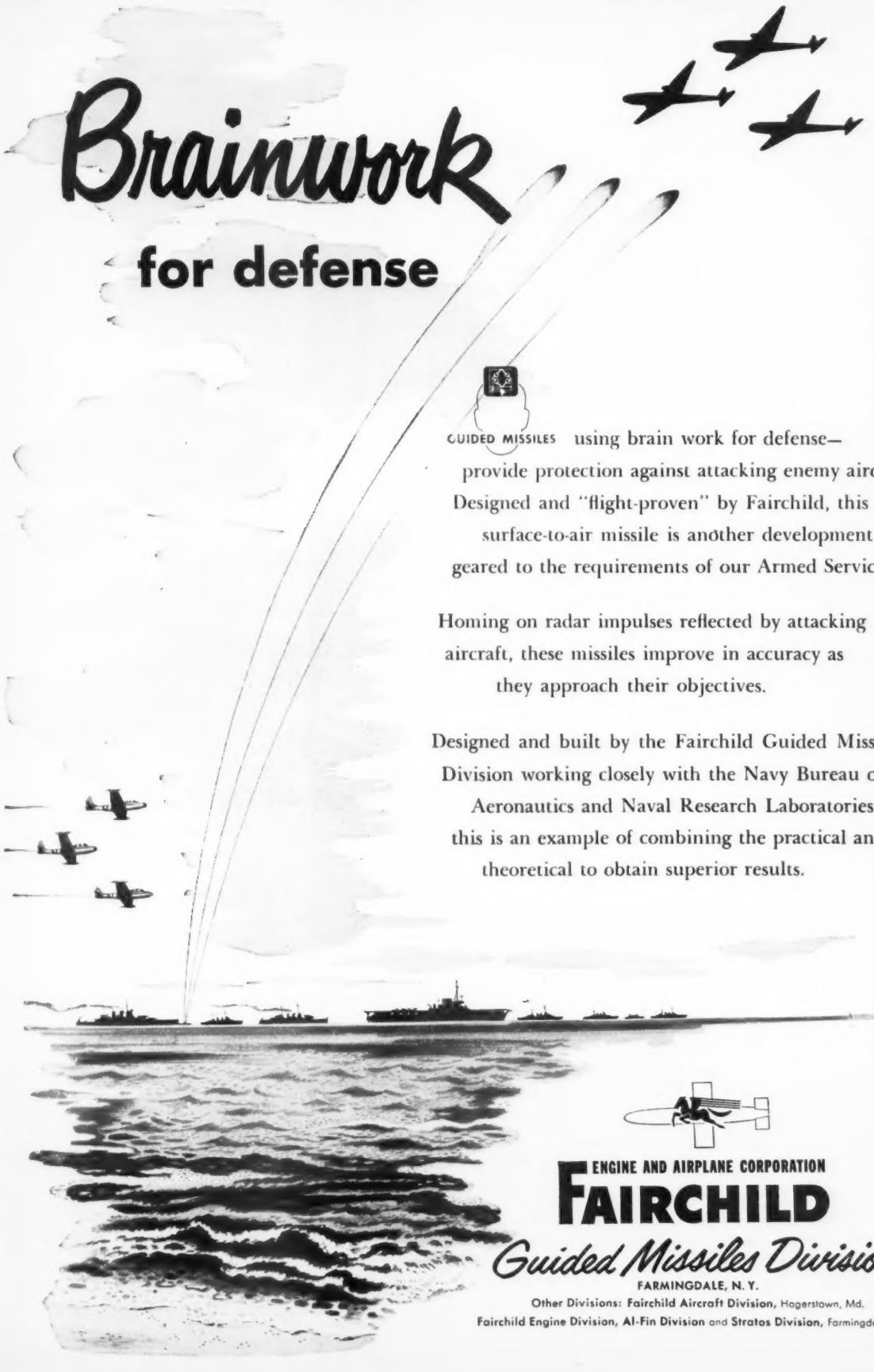
Cornell University

Thirty-one persons convened for the February 13 meeting at which Chairman Alfred Ritter presided. The speaker was Edward L. Resler, Jr., Research Associate, School of Aeronautical Engineering, Cornell, who gave an address on "Research on Strong Shock Waves."

On February 20, 32 persons gathered to hear C. Branson Smith, Project Engineer, Hamilton Standard Division, United Aircraft Corporation, speak on "Propellers for High-Speed Flight." Chairman Alfred Ritter presided.

University of Florida

On February 14, Commander Watkins, Planning Officer, Overhaul and Repair, Naval Air Station, Jackson-



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GUIDED MISSILES using brain work for defense—provide protection against attacking enemy aircraft. Designed and "flight-proven" by Fairchild, this surface-to-air missile is another development geared to the requirements of our Armed Services.

Homing on radar impulses reflected by attacking aircraft, these missiles improve in accuracy as they approach their objectives.

Designed and built by the Fairchild Guided Missiles Division working closely with the Navy Bureau of Aeronautics and Naval Research Laboratories, this is an example of combining the practical and theoretical to obtain superior results.

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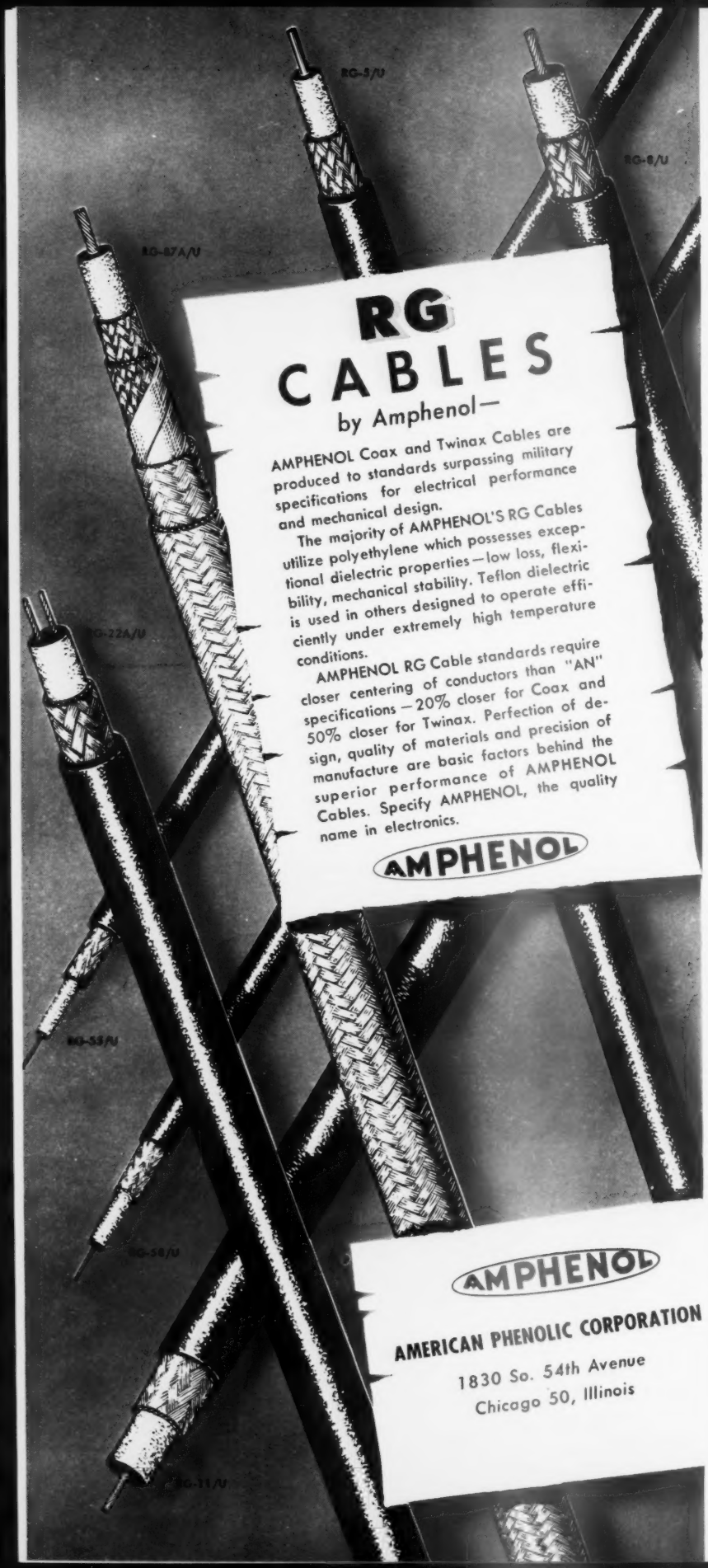
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AMPHENOL Coax and Twinax Cables are produced to standards surpassing military specifications for electrical performance and mechanical design.
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ville, Fla., presented a lecture on "Design Specifications, Planning, and Procurement in the Navy Department." Following his speech, two films were shown. The first one was *The NATIV* (North American Test Instrument Vehicle); the second was the *Special Showing of Latest Aircraft*. Chairman Costa Francisco presided; 35 persons attended.

Georgia Institute of Technology

Two films, *The Battle of Midway* and *Emergency Landing*, were shown at the February 2 meeting. Chairman Thomas C. Naughton led the meeting; 30 persons attended.

A film, *The True Glory*, was presented at the February 16 meeting. Chairman Thomas C. Naughton presided; 46 persons attended.

University of Illinois

Lieutenant Colonel F. W. Dooley, Professor, Air Science and Tactics, Air R.O.T.C., University of Illinois, gave a talk on "You and the Draft and the Air Force" at the January 10 meeting. Following his address, an election of officers took place with the following results: Chairman, Corliss Laisure; Vice-Chairman, James Watson; and Secretary-Treasurer, Elmer Schirmer. Chairman H. A. Wallskog presided; 35 persons were in attendance.

On March 7, Dr. J. M. Coan, Associate Professor of Aeronautical Engineering, spoke on "Job Opportunities for the Aeronautical Engineer." Vice-Chairman James Watson presided; 21 persons attended.

Indiana Technical College

Chairman Donald Wolfe opened the January 31 meeting at which 25 persons were present. Two films, *Faster Than Sound* and *Farnborough Air Show*, were screened.

Louisiana State University

Pierre Dupaquier was elected at the January 18 meeting to fill the vacancy in the position of secretary, created by the graduation of the former secretary this February. Chairman Robert Dawson presided; 17 persons attended.

New York University

Chairman James A. Miller was the presiding officer of the February 16 meeting at which the film, *The Story of the Flying Wing*, was shown. Sixty persons attended.

On February 21, the first social of the semester was held. It was attended by 50 members and their guests.

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Northrop Aeronautical Institute

An election of officers was held at the February 15 meeting with the following results: Chairman, J. C. Chaffee; Vice-Chairman, E. F. Noel; Secretary, H. G. Young; and Treasurer, L. M. Nelson. Chairman H. D. Moran presided; 56 persons attended.

A North American film, *Structures*, was shown at the March 7 meeting. Chairman Chaffee presided; 70 persons were present.

University of Notre Dame

On February 15, the following officers were elected: Chairman, David Medwid; Vice-Chairman, Gordon Brickson; Secretary, William Grunske; and Treasurer, James Foley.

The Ohio State University

A field trip was made on February 23 to Wright-Patterson Air Force Base, Ohio, where a conducted tour of the base's general activities was made. Thirty-five persons made the trip.

The University of Oklahoma

On February 22, a joint meeting was held with the S.A.E. and A.S.M.E. student branches. The speaker was Dr. F. D. Frey, Chief Chemist, Deeprock Oil Company, who presented a talk on "Present-Day Lubricants." David N. Grimes, President, S.A.E. Student Branch, presided. The total attendance was 55.

Oregon State College

On February 21, a motion picture, *Target for Tonight*, was presented. Chairman Richard L. Sears presided; 11 persons attended.

Purdue University

On February 14, Chairman Richard Max Clayton led the meeting attended by 90 persons. Dr. Milton U. Clauser, Head, School of Aeronautics, and Merrill E. Shanks, Professor of Mathematics and Aeronautics, spoke on problems involved in the axial-flow compressor design of a jet engine.

Stanford University

On February 23, ten persons went on a field trip to United Helicopters, Inc., where they were shown through the plant by D. R. Jacoby, Chief Aerodynamicist.

Agricultural & Mechanical College of Texas

Fred E. Weick, Director, Personal Aircraft Research Center, Texas A. & M., lectured on "Safety and the Agricultural Airplane" at the November 8 meeting. Chairman Robert Bryan English presided; 20 persons attended.

On December 13, a joint I.A.S.-S.A.E. student branch meeting was held. Mr. Guyton, Test Pilot, Chance Vought Aircraft Division, United Aircraft Corporation, spoke on "The Chance Vought Cutlass." S.A.E. President Richard R. Tumlinson presided; 85 persons attended.

Chairman English led the February 28 meeting at which a film, *Tacoma Narrows Bridge*, was shown. Ten members were present.

Tri-State College

On February 1, an Aluminum Company of America film, *Curiosity Shop*, was shown to the 20 persons present. Chairman Don M. Carroll presided.

On February 15, another Alcoa film, *This Is Aluminum*, was screened. This was followed by a Sperry Gyroscope Company film, *Gyrosyn Compass*. Twenty-four persons were in attendance, with Chairman Carroll presiding.

Wayne University

On January 9, the following were elected to office: Chairman, Ronald Barcus; Vice-Chairman, Roman E. Baruta; Treasurer, Harold Bryman; and Secretary, Gerald L. Goldberg. Vice-Chairman Floyd Jones presided; 12 persons attended.

West Virginia University

On February 8, a film entitled *Rain* was shown to the 11 attending persons. Chairman Sam Hill presided.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Smelt, Ronald, M.A., Chief, Gas Dynamics Facility, ARO, Inc.

Transferred to Associate Fellow Grade

Diederich, Franklin W., M. of Ae.E., Aero. Research Scientist P-6, N.A.C.A., Langley Air Force Base; Lecturer in graduate engineering subjects, University of Virginia.

Dobson, Franklin A., B.S., Project Engineer in Charge of Structural Research, Aerophysics Lab., North American Aviation, Inc.

Mangurian, George N., S.M. in Civil Engineering, Chief Structural Engineer, Northrop Aircraft, Inc.

Elected to MEMBER Grade

Argall, Frank L., Dir. of Training of Aero. Engineering School, Cal-Aero Technical Institute.

Baldwin, Robert J., B.S., Project Engineer, McDonnell Aircraft Corp.

Bishop, Paul M., B.S., Staff Engineer, Equipment Planning, American Airlines, Inc.

Carey, John C., B.S.E.E., Chief Engineer, Western Design & Mfg. Corp.

Golkowske, William G., Chief of Region III, Civil Aeronautics Board, Bureau of Safety Investigation.

Halfman, Robert L., S.M. in Ae.E., Asst. Prof. of Aero. Engineering, Massachusetts Institute of Technology.

Himka, Theodore, B.S. in A.E., Aerodynamicist, Sverdrup & Parcel, Inc.

Hodson, Roy F., Project Engineer, Aircraft Analysis Section, American Airlines, Inc.

Holliday, Ivar M., B.S.M.E., Research Physicist, Computers & Controls Section, Research & Development Lab., Hughes Aircraft Co.

Jaworski, Adam, LL.D., Aero. Research Engineer, Air Transport Board (Canada).

King, B. Wensley, B.Sc. (Civil Engineering), Managing Dir., Sperry Gyroscope Co. of Canada, Ltd.

Klein, Frank D., S.B., Head, Aviation Group, Engineering Div., Marketing Dept., Esso Standard Oil Co.

Lawrence, Alfred N., B.S. in E.E., Mgr., Eastern Office, Lear, Inc.

Mirowitz, Leo I., B.S.E.E., Sr. Research Engineer, McDonnell Aircraft Corp.

Pearson, Ernest O., Jr., B.S.M.E., Staff of the Dir.; Asst. Chief, Aerodynamic Research Div., N.A.C.A. Hdqs. (Washington, D.C.).

Quinn, John J., A.E., Engineering Test Pilot, Northrop Aircraft, Inc.

Reichel, Andre W., Engineering Coordinator, Kearfott Co., Inc.

Steele, Harry M., Jr., M.E., Research Engineer, Aerodynamics, Hughes Aircraft Co.

Swartz, Jerry M., Design & Liaison Engineer, Lockheed Aircraft Service Corp.

Ungashick, Thomas W., B.S.M.E., Chief Production Project Engineer, Fairchild Guided Missiles Div., Fairchild Engine & Airplane Corp.

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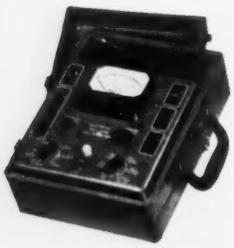

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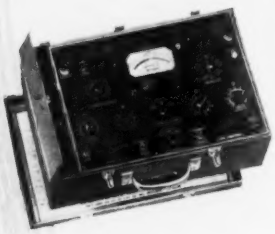

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Auld, Charles D., B.Ae.E., Asst. Head, Wind Tunnel I, Aero. Lab., David Taylor Model Basin, Dept. of the Navy.

Broadbooks, Norman B., B.S. in Ae.E., Aerodynamicist, North American Aviation, Inc.

Connelly, John J., Jr., B.Ae.E., Lt. (j.g.), U.S.N.; Airframes Officer, Naval Multi-Engine Patrol Squadron, Naval Air Station (Patuxent River).

Griffin, Bradford J., Assoc. Sc. in Ae.E., Layout Draftsman, Guided Missile Group, Grumman Aircraft Engineering Corp.

Haneman, Vincent S., Jr., M.S. in Ae.E., Research Engineer, Engineering Research Institute, Aero. Engineering Dept., University of Michigan.

Hurc, Cass F., B.S. in Ae.E., Head, Aero. Engineering Drawing & Lofting, The Aero. University, Inc.

Lindow, Carl V., A.A. in Ae.E., Asst. Chief Stress Engineer, A. V. Roe Canada Ltd.

Marth, Verlyn G., B.S. in Ae.E., Flight Test Engineer, Douglas Aircraft Co., Inc. (Santa Monica).

Morrow, William J., B.S.Ae.E., Aircraft Power Plant Design & Development Engineer, Air Materiel Command, Wright-Patterson Air Force Base.

Shieber, Herbert, B.S. in C.E., Structural Test Engineer, McDonnell Aircraft Corp.

Woodworth, Joseph E., M.S., Aerodynamicist, Douglas Aircraft Co., Inc. (El Segundo).

Zmola, Paul C., Ph.D., Development Engineer, Oak Ridge National Lab.

Elected to Associate Member Grade

Bobrick, Arthur L., President, Bobrick Mfg. Corp.

Hull, Clyde W., Jr., Mgr. of New York Office, Solar Aircraft Co.

Laskowitz, Isidor B., M.E., Independent Research—Design & Development of Rotary Wing Aircraft.

Elected to Technical Member Grade

Bellian, W. Seaton, Technician, Flight Testing of Gas Turbine Engines, A. V. Roe Canada Ltd. (Malton).

Kalstad, Henry M., B.S.Ae.E., Lt., U.S.N.; Asst. Engineering Officer & Maintenance Cost Accounting Officer, Westover Air Force Base.

McKee, Ralph D., Major & Rated Aerial Navigator, U.S.A.F.

New, Noah C., M.S., 1st Lt. & Pilot, U.S.M.C.R., M.C.A.S. (Quantico).

Newell, Joseph S., Jr., B.S., Structures Engineer, Bell Aircraft Corp.

Nordling, Olof V. Tore, Civ. Ing., Instructor, Royal Institute of Technology; Project Engineer, Royal Swedish Air Board.

Smiley, Robert F., B.S. in E.E., Aero. Research Scientist GS-9, Landing Loads Branch, N.A.C.A., Langley Air Force Base.

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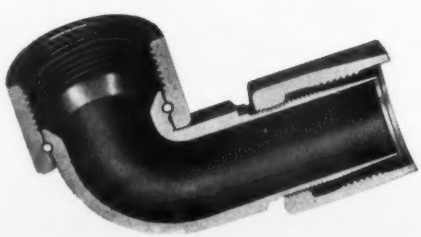

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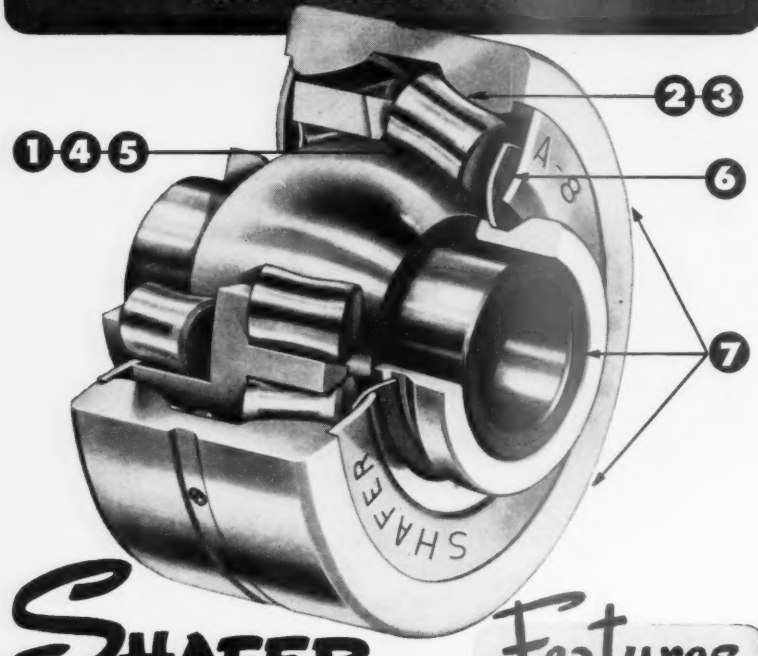

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Transferred to Technical Member Grade

Armstrong, William A., Engineering Draftsman "B," North American Aviation, Inc.

Bachman, John A., Jr., B. of A.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Baldwin, Richard, B.S.Ae.E., Hydraulic Development Engineer, Automatic Switch Co.

Barrett, Anthony J., M.S. in Ae.E., Stress Analyst, Handley Page, Ltd.

Bartel, Cecil Ray, Sr. Detailer, Design Group, Chance Vought Aircraft Div., United Aircraft Corp.

Briggs, Phillip E., Layout Draftsman, Power Generators, Ltd.

Broere, Richard B., B.S.

Brook, John C., B.S.Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Cady, Joseph G., B.S. in Ae.E. Graduate Asst., College of Applied Science, Syracuse University.

Carlisle, Thomas S., B. of Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Wichita).

Carter, Arthur M., Jr., M.S. in Ae.E., Lt. Comdr., U.S.N.; Asst. Superintendent, Aero. Materials Lab., Naval Air Material Center, Naval Air Experimental Station (Philadelphia).

Caruso, Charles P., B.S. in A.E., 2nd Lt., U.S.A.F.

De Carlo, Joseph, Teacher, Constr. & Maintenance, Sikorsky Aircraft Div., United Aircraft Corp.

Delaney, Jack, Jr.

Eisenhart, Robert D., B.S. in Ae.E., Jr. Engineer "A," Boeing Airplane Co. (Seattle).

Felder, Harry, B. of Ae.E., Design Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Foss, Warren L., B.S., Capt. & Inspector, I.G. Unit, U.S.A.F.

Gorse, Norville J., B.S.Ae.E., Pilot, Design & Development Officer (Aircraft), U.S.A.F.R.

Gourd, Paul E., Lt. & Navigator, U.S.A.F.

Grande, Donald L., B.S. in Ae.E., Engineering Technician, Lockheed Aircraft Corp.

Greenwood, John E., Stress Engineer, North American Aviation, Inc.

Hooper, Alton V., B.S., Aero. Engineer, Sverdrup & Parcel, Inc.

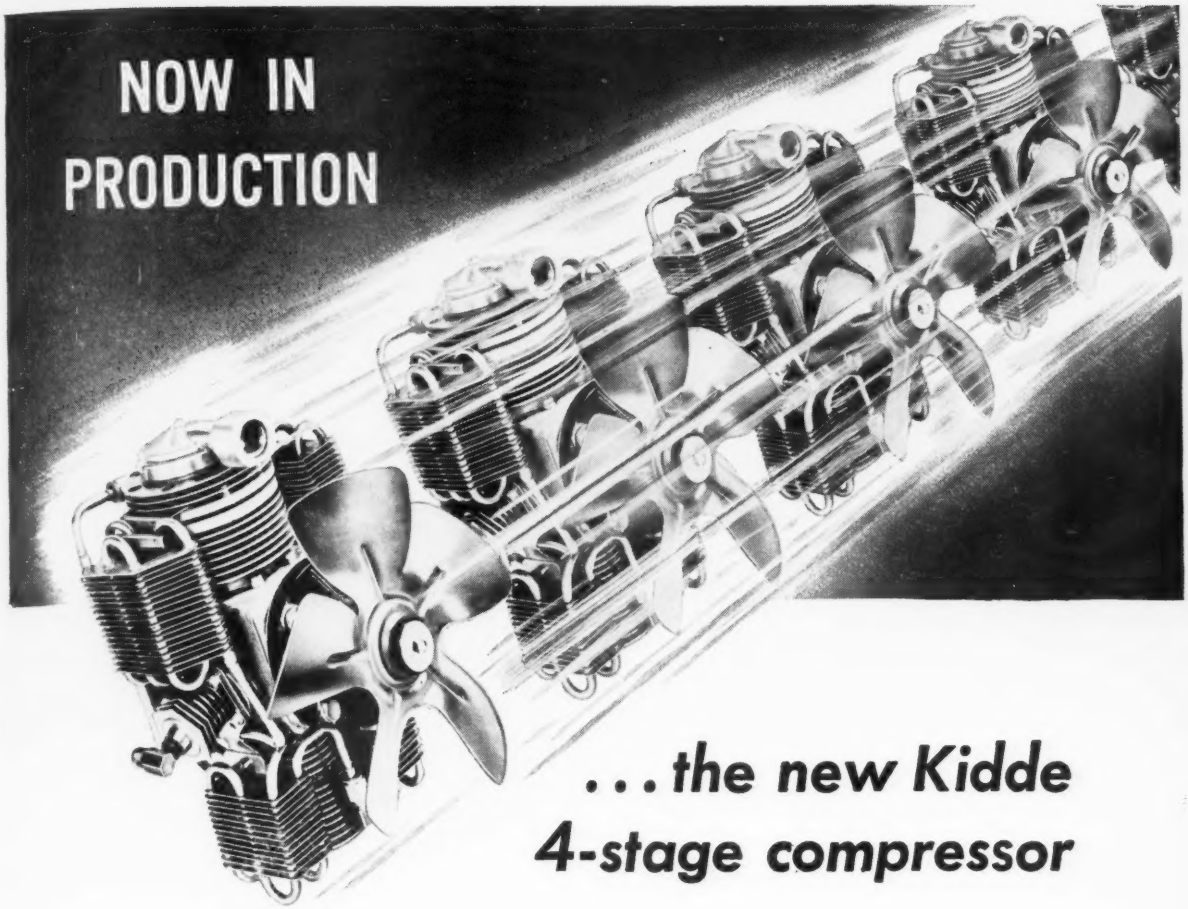
Horner, William B., B.S. in Ae.E., Stress Analyst, North American Aviation, Inc.

Justin, Joseph W., Engineering Draftsman, North American Aviation, Inc.

Kvietkus, John, B.S.Ae.E., Designer, Boeing Airplane Co. (Seattle).

LaBella, Sebastian.

Lorenz, Bernard C., B.S.Ae.E., 2nd Lt. & Pilot Trainee, U.S.A.F.



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Mathis, Kenneth A., Aero. Mathematician, Northrop Aircraft, Inc.

Mayer, Martin A., B.S.Ae.E., Engineering Trainee (Material Control), Foote Bros. Gear & Machine Corp.

Metcalfe, Kenneth C., B.S. (Aero.), Designer "B," Engineering Div., Boeing Airplane Co. (Seattle).

Metz, Theodore R., B.E. in M.E. (Aero.), Aerodynamicist, North American Aviation, Inc.

Naegele, Robert J., II, B.S., Aerodynamicist, Lockheed Aircraft Corp.

Nelms, William L., Tech. Sgt.—Airplane Maintenance Technician (Inspector), U.S.A.F.

Nuschke, Charles L., B.S. in Ae.E., 2nd Lt. & Pilot Trainee, U.S.A.F.

Pryor, Howard M., Capt., U.S.A.F.; Procurement Project Officer, Procurement Div., Hdqs., Air Materiel Command, Wright-Patterson Air Force Base.

Rodenbaugh, William L., B.S.A.E., Jr. Engineer, Research Dept., Wright Aero. Corp. Div., Curtiss-Wright Corp.

Schultz, Edwin R., B.S.Ae.E., Aero. Engineer, McDonnell Aircraft Corp.

Shields, Mack E., B.S. in Ae.E., Jr. Engineer, Aerodynamics Section, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Sparre, Erik, B. of Ae.E., Aircraft Engineer "B," Airframe Engineering Section, Engineering Dept., United Air Lines, Inc.

Stockstill, Charles J., B.S., 2nd Lt. & Navigation Student, U.S.A.F.

Tarr, John, B.S.Ae.E., Jr. Engineer, Piasecki Helicopter Corp.

Weatherly, Lloyd H., Jr., B.S.Ae.E., Asst. Division Engineer, Aircraft & Machine Tools Div., S.K.F. Industries, Inc.

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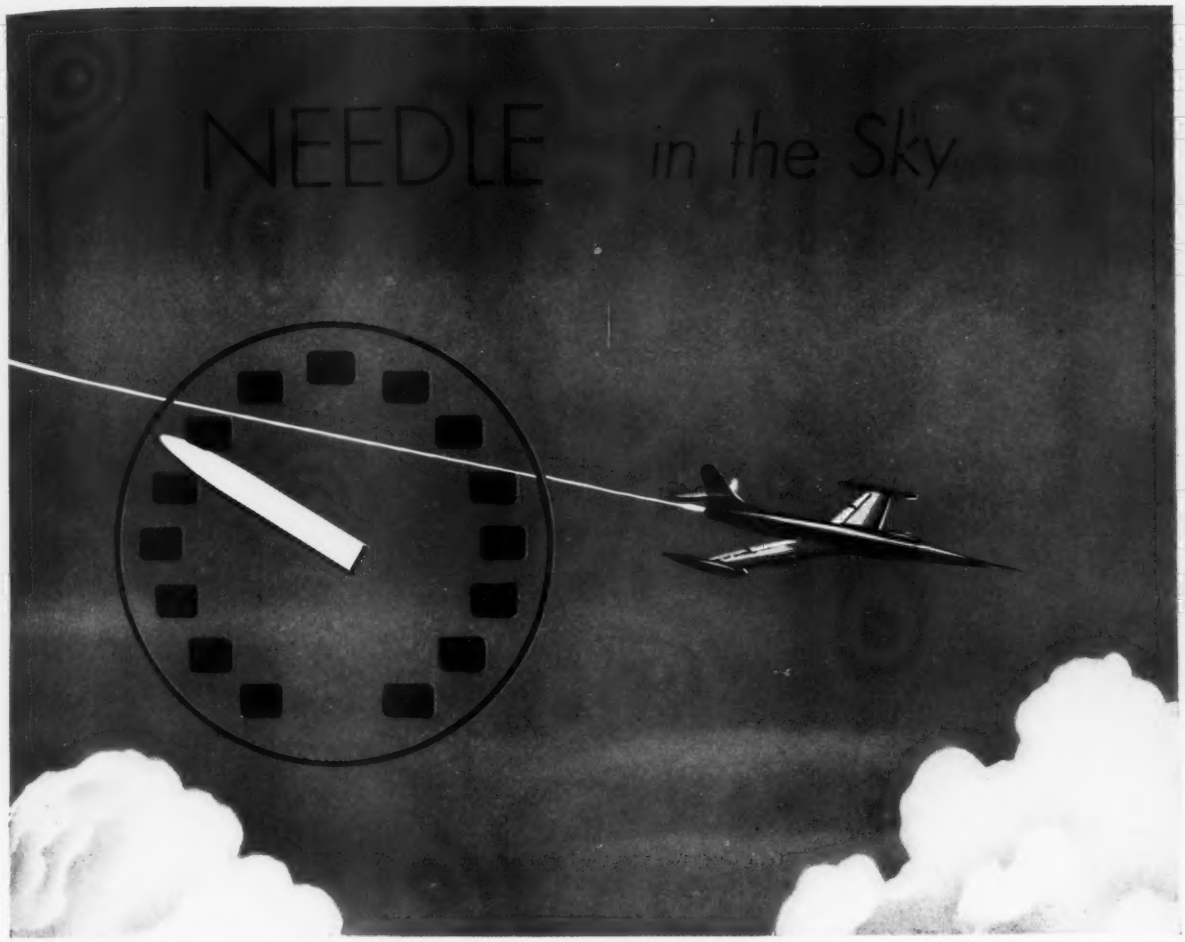

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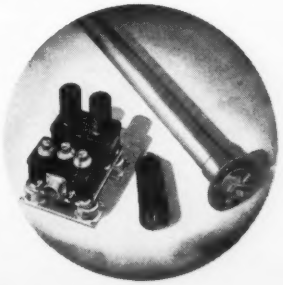

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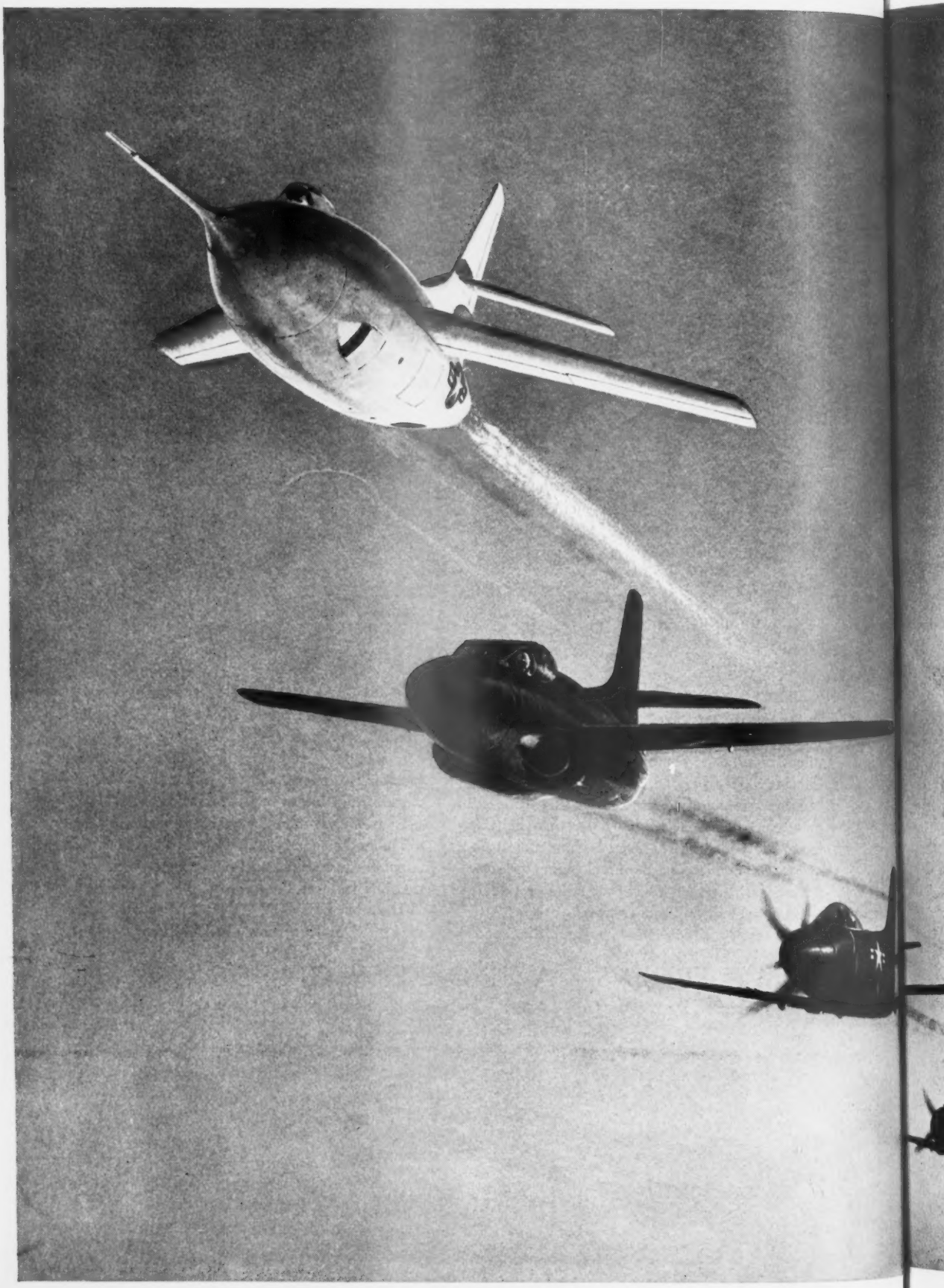

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In 1950 the twin-jet F3D Skyknight was started down the production line at El Segundo, following enthusiastic reports from Navy test pilots.

Now being flight tested in preparation for line production is the A2D Skyshark, turbo-prop attack plane. And above Edwards Air Base the rocket-powered D-558-2 Skyrocket is thrusting its needle-nose into the thin air, looking for scientific data that will help build newer type aircraft still in the classified status.

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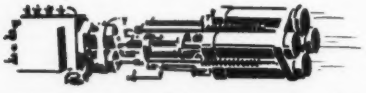
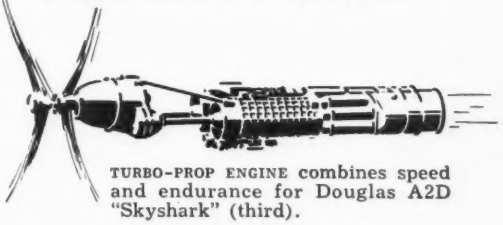


ROCKET ENGINE delivers supersonic speed for Douglas "Skyrocket" (top).



TURBO-PROP ENGINE combines speed and endurance for Douglas A2D "Skyshark" (third).

TWIN-JET ENGINE gives pure jet thrust for Douglas F3D "Skyknight" (second).

RECIPROCATING ENGINE provides work-horse efficiency for Douglas AD "Skyraider" (bottom).

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Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

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The following periodicals currently provide source material for the Reviews Section of the *Aeronautical Engineering Review*. Received regularly, these magazines and reports (both domestic and foreign) are thoroughly screened each month by the Institute's technical editorial staff. Articles and items of technical value to the aeronautical profession are abstracted or listed for further reference.

Not included in this list are hundreds of irregularly published reports, releases, house organs, etc., which are also screened and reviewed as they appear. Unless otherwise indicated, the publications in this list are issued in the U.S. All publications reviewed are permanently filed in the I.A.S. libraries.

Trade Publications—English Language

Aero Digest
Aeronautics (England)
The Aeroplane (England)
Aeroporika Nea (Greece)
Air Affairs
Air Facts
Air Pictorial (England)
Air Trails Pictorial
Air Transportation
Aircraft (Australia)
Aircraft & Airport (Canada)
Aircraft Engineering (England)
Aircraft Production (England)
The Air-Log (Australia)
Airports & Air Transportation (England)
American Aviation
American Helicopter
Applied Hydraulics
Audio Engineering
Automotive Industries
Aviation Age
Aviation Week
Canadian Aviation (Canada)
Diesel Power & Diesel Transportation
Distribution Age
Electronic Engineering (England)
Electronics
The Electronics Forum (England)
The Engineer (England)
The Engineers' Digest (England)
Flight (England)
Flight Magazine
Flying
Flying (New Zealand)
The Indian Airman (India)
Indian Skyways (India)
Instruments
Interavia (Switzerland)
Journal of Atmospheric and Terrestrial Physics (England)
Machine Design
Maritime & Aviation Magazine (Ireland)
Materials & Methods
Modern Metals
Modern Transport (England)
The Philosophical Magazine (England)
Product Engineering
Quarterly Journal of Mechanics and Applied Mathematics
Radio & Television News (Electronic Engineering Edition)
Sailplane & Glider (England)
Sheet Metal Industries (England)
Skyways
Steel Processing
U.S. Air Services
Western Flying
Whites Aviation (New Zealand)
Wings (Australia)

Trade Publications—Foreign Language

Aeronáutica (Venezuela)
Aeronáutica Continental (Argentina)
Les Ailes (France)
L'Air (France)
L'Ala (Italy)
Alata (Italy)
Argentina Aérea (Argentina)
Avia (Argentina)
Aviação (Brazil)
Aviación (Argentina)
L'Aviation Marchande (France)
Avión (Spain)
Chile Aéreo (Chile)
L'Echo des Ailes (Belgium)
Flugwehr und -Technik (Switzerland)
Ilmailu (Finland)
Ingeniería Aeronáutica (Spain)
Inter-Auto (Italy)
La Médecine Aéronautique (France)
Mundo Aeronáutico (Argentina)
Propel (Denmark)
Revista Aérea Cubana (Cuba)
Revista Aérea Latinoamericana (U.S.)
Revista Nacional de Aeronáutica (Argentina)
Revue Générale de l'Air (France)
Rivista di Meteorologia Aeronautica (Italy)
Romania Aeriana (Romania)
Schweizer Aero-Revue (Switzerland)
Tecnica Italiana (Italy)
Teknikens Värld, med Flyg (Sweden)
Thermik (Germany)
Velocidade (Brazil)
De Vliegende Hollander (Netherlands)
Vliegwereld (Netherlands)
Vingpennor (Sweden)
Weltluftfahrt (Germany)

Society, University, and Specialized Publications

Acta Polytechnica, Chemistry, Including Metallurgy, Series (Sweden)
Acta Polytechnica, Civil Engineering and Building Construction Series (Sweden)
Acta Polytechnica, Engineering Series (Sweden)
Acta Polytechnica, Mathematics Series (Sweden)
Acta Polytechnica, Mechanical Engineering Series (Sweden)
Aéro Club de France, Revue (France)
Aero Research Technical Notes (England)
Aeronautical Engineering Review
The Aeronautical Quarterly (England)
Aeronautical Society of India, Journal (India)
L'Aerotecnica (Italy)
Agricultural & Mechanical College of Texas, Engineering Experiment Station, Bulletin
Aircraft Heating Digest
Allis-Chalmers Electrical Review
American Chemical Society, Journal
American Journal of Physics
American Meteorological Society, Bulletin
American Rocket Society, Journal
A.S.T.M., Bulletin
A.S.T.M., Proceedings
A.S.M.E., Transactions
Analytical Chemistry
Antiaircraft Journal
Astro-Jet
The Bee-Hive
The Bell System Technical Journal
Boeing Magazine
Boeing Service Guide
British Interplanetary Society, Journal (England)
British Journal of Applied Physics (England)
Les Cahiers d'Aérodynamique (France)
Canadian de Havilland Gazette (Canada)
Chemical & Engineering News
Chinese Journal of Physics (China)
Círculo de Aviación, Revista (Argentina)
Club de Turismo Venezolano, Revista (Venezuela)
Communications on Pure and Applied Mathematics
Cornell Aeronautical Laboratory, Inc., Translations and Selected Reports
Corrosion
Cranfield, College of Aeronautics, Reports (England)
Creer (France)
de Havilland Gazette (England)
Delft, Technische Hogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededelingen (Netherlands)
Douglas Service
Electrical Communication
Electrical Engineering
The Engineering Journal (Canada)
Ericsson Technics (Sweden)
Esso Air World (England)
Flight Lines
Franklin Institute, Journal
General Electric Review
Guild of Air Pilots and Air Navigators, Journal (England)
Hawker Siddeley Review (England)
Helicopter Association of Great Britain, Bulletin (England)
I.A.S. Sherman Fairchild Publications
Illinois Technograph
Illinois University, Bulletin, Bulletin Series

Illinois University, Bulletin, Circular Series
Illinois University, Institute of Aeronautics, Bulletin
Industrial & Engineering Chemistry
Industrial Quality Control
Institut Royal Météorologique, Mémoires (Belgium)
Institut Royal Météorologique, Miscellanées (Belgium)
Institute of Navigation, Journal (England)
Institute of Radio Engineers, Proceedings
Institute of Transport, Journal (England)
Institute of Welding, Transactions (England)
Institution of Electrical Engineers, Proceedings, Parts I, II, and III (England)
Institution of Mechanical Engineers, Proceedings (England)
Instrumentation
Istanbul, University, Faculty of Science, Revue, Series A: Mathematics, Physics, and Chemistry (Turkey)
Istanbul, University, Faculty of Science, Revue, Series B: Natural Sciences (Turkey)
Journal of Air Law & Commerce
Journal of Applied Mechanics
Journal of Applied Physics
Journal of Aviation Medicine
Journal of Engineering Education
Journal of Mathematics & Physics
Journal of Meteorology
Journal of Scientific Instruments (England)
Journal of Southern Research
Journal of the Aeronautical Sciences
Journal Scientifique de la Météorologie (France)
The Log (England)
Lubrication
The Martin Star
Mechanical Engineering
The Military Surgeon
The National Air Review
National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin
Navigation
Ohio State University, Engineering Experiment Station, News
Ordnance
Oregon State College, Engineering Experiment Station, Bulletin
The Pegasus
Photogrammetria (Netherlands)
Photogrammetric Engineering
Pisa, University, Faculty of Engineering, Pubblicazioni (Italy)
La Plata, University, Faculty of Physicomathematical Sciences, Institute of Aeronautics, Publicación (Argentina)
Prague, Letecký Výzkumný Ústav (Aeronautical Research Institute), Reports (Czechoslovakia)
Professional Engineer
Protar (Switzerland)
Quarterly of Applied Mathematics
RCA Review
Review of Scientific Instruments
La Ricerca Scientifica (Italy)
Rivista Aeronautica (Italy)
Rivista di Medicina Aeronautica (Italy)
Rocketscience
Royal Aeronautical Society, Journal (England)
Royal Meteorological Society, Quarterly Journal (England)
Royal Society (London), Proceedings, Series A: Mathematical and Physical Sciences (England)
Royal Society (London), Philosophical Transactions, Series A: Mathematical and Physical Sciences (England)
Saab Sonics (Sweden)
SAE Journal
SAE Quarterly Transactions
Shell Aviation News (England)
Skrzydła i Motor (Poland)
Skrzydłata Polska (Poland)
Soaring
Society of Applied Mechanics of Japan, Journal (Japan)
Society of Instrument Technology, Transactions (Australia)
Sperryscope
Standards World
Taylor Technology
The Technical Instructor (England)
Technique et Science Aéronautiques (France)
The Technology Review
Teknisk Tidskrift (Sweden)
Timisoara, Polytechnique, Bulletin de Science et Technique (Romania)
The Tool Engineer
The Trend in Engineering
Tucumán, University, Revista, Series A: Mathematics & Theoretical Physics (Argentina)
Turin, Politecnico, Laboratorio di Aeronautica, Monografie (Italy)
U.S. Naval Institute, Proceedings
Weatherwise
Weltraumfahrt
Western Union Technical Review
Wings (New Zealand)
Zurich, Eidgenössische Technische Hochschule, Institut für Aerodynamik, Mitteilungen (Switzerland)
Zurich, Eidgenössische Technische Hochschule, Institut für Flugzeugstatik und Flugzeugbau, Mitteilungen

Government Publications

Australia

Australian Journal of Applied Science
Australian Journal of Scientific Research, Series A: Physical Sciences
Council for Aeronautics, Reports
Commonwealth and Industrial Research Organization, Division of Radiophysics, Reports
Department of Supply and Development, Aeronautical Research Laboratories, Reports

Belgium

Service Technique de l'Aéronautique, Bulletin

Canada

Canadian Journal of Physics
Canadian Journal of Technology
National Research Council, Aeronautical Notes
National Research Council, Aeronautical Reports
National Research Council, Reports
National Research Council, Aeronautical Laboratories, Quarterly Bulletin

Chile

Revista de la Fuerza Aérea

Ireland

Department of Industry and Commerce, Meteorological Service, Technical Notes

France

Ministère de l'Air, Publications Scientifiques et Techniques
Ministère de l'Air, Publications Scientifiques, Bulletins des Services Techniques
Ministère de l'Air, Publications Scientifiques et Techniques, Notes Techniques
O.N.E.R.A., Publications
O.N.E.R.A., Rapports Techniques
La Recherche Aéronautique

Great Britain

Aeronautical Research Council, Reports & Memoranda
Aeronautical Research Council, Current Papers
Inter-Services Aircraft Recognition Journal
Meteorological Office, Meteorological Magazine
Meteorological Office, Professional Notes

India

Journal of Scientific & Industrial Research

Italy

Ministry of Defense—Aeronautics, Monografie Scientifiche di Aeronautica

Japan

Papers in Meteorology and Applied Physics

Netherlands

Nationaal Luchtvaartlaboratorium, Rapport, Series A, F, S, and V
Nationaal Luchtvaartlaboratorium, Reports and Transactions

Spain

Revista de Aeronáutica

Sweden

Flygtekniska Försöksanstalt, Meddelande
Kungl. Tekniska Högskola, Institution för Flygteknik (Royal Institute of Technology, Division of Aeronautics), Technical Notes
Royal Swedish Air Board, Translations

U.S.S.R.

Akademiia Nauk, Doklady

U.S.

Aero Medical Laboratory, Memorandum Reports
Air Force Library, Translations
Air Materiel Command, Engineering Division, Reports
Air Materiel Command, Technical Reports
Air Materiel Command, Translations
Air University Quarterly Review
C.A.A., Flight Engineering Reports
C.A.A., Technical Development Reports
C.A.A., Division of Research, Reports
C.A.A. Journal
Contact (U.S. Navy, School of Aviation Medicine, Pensacola, Fla.)
Forest Products Laboratory, Progress Reports
Forest Products Laboratory, Technical Notes
N.A.C.A., Reports
N.A.C.A., Research Memorandums
N.A.C.A., Technical Memorandums
N.A.C.A., Technical Notes
N.B.S., Journal of Research
N.B.S., Technical News Bulletin
N.B.S., Technical Reports
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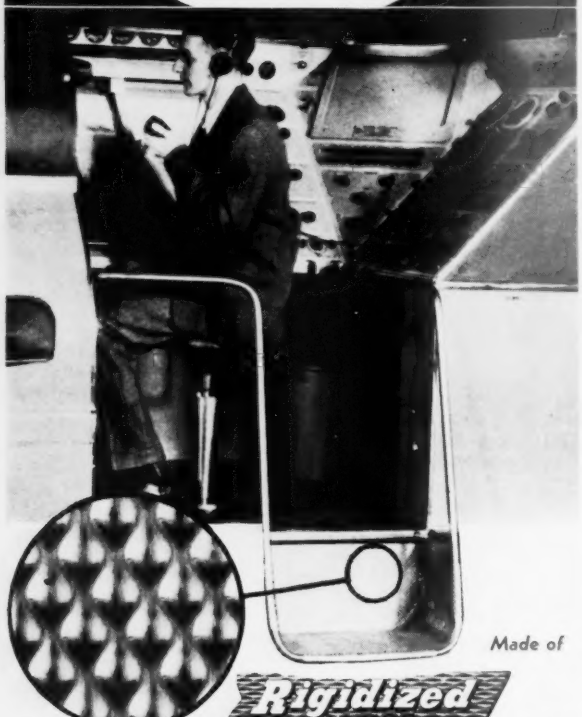

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Aerodynamics (2)

High Speed Aerodynamic Problems of Turbojet Installations. H. Luskin and H. Klein. (*American Society of Mechanical Engineers, Annual Meeting, New York, December, 1950, Preprint.*) *Douglas Aircraft Company, Inc., Report No. SM-13839*, September 1, 1950. 71 pp., illus. 18 references. Analysis of the performance requirements of a turbojet installation from the standpoint of the aerodynamics of a high-speed airplane.

BOUNDARY LAYER

The Interaction of Shock Waves with Boundary Layers on a Flat Surface. F. W. Barry, A. H. Shapiro, and E. P. Neumann. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 229–230, 270, illus. 11 references.

Results of tests in the M.I.T. 8- by 8-in. wind tunnel at a Mach Number of 2.05 and Reynolds Numbers of 1.1, 2.5, 6.0, and 12×10^6 are presented in the form of schlieren photographs that show the interaction of shock waves produced by a shock generator (airfoil) with the boundary layer of a flat plate.

Influence of Wall Boundary Layer upon the Performance of an Axial-Flow Fan Rotor. Emanuel Boxer. *U.S., N.A.C.A., Technical Note No. 2291*, February, 1951. 21 pp., illus. 3 references.

Readers' Forum: On the Theory of Heat Transfer Through a Laminar Boundary Layer. Arthur N. Tifford. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, pp. 283, 284. 4 references.

The Laminar Boundary Layer on a Rotating Blade. Laurence Eugene Fogarty. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 247–252, illus. 11 references.

Development of the boundary-layer equations for a blade rotating steadily in an incompressible fluid. The analysis deals with the portion of a blade of infinite span which is several chord lengths from the axis of rotation, but results are applicable over a large portion of the span of high-aspect-ratio blades.

On Stability of Free Laminar Boundary Layer Between Parallel Streams. Martin Lessen. *U.S., N.A.C.A., Report No. 979*, 1950. 9 pp., illus. 22 references. Superintendent of Documents, Washington. $0.15.

The Tollmien-Schlichting theory of small disturbances is used to analyze and calculate the stability of the free laminar boundary layer between parallel streams of semi-infinite extent in an incompressible fluid. The solution is carried out for a flow in which one of the streams is assumed to be at rest.

Turbulent Boundary-Layer Temperature Recovery Factors in Two-Dimensional Supersonic Flow. Maurice Tucker and Stephen H. Maslen. *U.S., N.A.C.A., Technical Note No. 2296*, February, 1951. 21 pp., illus. 13 references.

An extension of Squire's low-speed analysis of incompressible flow to the case of two-dimensional supersonic flow along a thermally-insulated surface. The variation of turbulent temperature velocity factor is tabulated for a Prandtl Number of 0.65, 0.70, 0.75 and for a Mach Number of 0, 3, 6, 10 for various values of the velocity parameter.

An Analytical and Experimental Investigation of the Skin Friction of the Turbulent Boundary Layer on a Flat Plate at Supersonic Speeds. Morris W. Rubesin, Randall C. Maydew, and Steven A. Varga. *U.S., N.A.C.A., Technical Note No. 2305*, February, 1951. 38 pp., illus. 18 references. Critical review of various analyses of the prediction of skin friction on a flat plate with a compressible turbulent boundary layer; experimental evaluation.

CONTROL SURFACES

Estimation of Low-Speed Lift and Hinge-Moment Parameters for Full-Span Trailing Edge Flaps on Lifting Surfaces with and Without Sweepback. Jules B. Dods, Jr. *U.S., N.A.C.A., Technical Note No. 2288*, February, 1951. 47 pp., illus. 10 references. Development of a method based on lifting-surface theory. Sample calculations are presented for one airfoil.

Method for Calculating Lift Distributions for Unswept Wings with Flaps or Ailerons by Use of Nonlinear Section Lift Data. James C. Sivells and Gertrude C. Westrick. *U.S., N.A.C.A., Technical Note No. 2283*, January, 1951. 63 pp., illus. 9 references.

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FLUID MECHANICS & AERODYNAMIC THEORY

Fluid Motions Whose Kinematics Are Independent of the Compressibility of the Fluid. D. H. Parsons. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 4, December, 1950, pp. 446–451. General account of the theory.

Experimental Measurement of Incompressible Flow Along a Cylinder with a Conical Nose. E. V. Laitone. *Journal of Applied Physics*, Vol. 22, No. 1, January, 1951, pp. 63, 64, illus. 2 references.

Comparison of test results on two aluminum bodies, each with a conical nose and a cylindrical afterbody, at zero angle of attack, $M = 0.10$, and $R = 2.5 \times 10^6$. The models were tested in the 3- by 3-ft. open-throat wind tunnel at the University of California at Berkeley.

The Method of Singularities for the Determination of Forces and Moments Acting on a Body in Potential Flow. A. Betz. (*Ingenieur-Archiv*, 1932.) *U.S., Navy Department, David W. Taylor Model Basin, Translation No. 241*, November, 1950. 13 pp., illus. 2 references.

The flow around a body is reproduced by the superposition of the undisturbed flow of sources, sinks, potential vortices, or similar simple flows having singular points. The manner of superposition determines the resulting flow field. The forces acting on the body are determined from these singularities and from the known undisturbed flow. The process is developed for steady flow; the resulting formulas are valid for both line and point singularities.

Sphere Drag Data at Supersonic Speeds and Low Reynolds Numbers. E. D. Kane. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 259–270, illus. 27 references.

Measurement of the drag on spheres in a low-density supersonic tunnel at Mach Numbers of 2.1 to 2.8 and a Reynolds Number range (based on free-stream properties and sphere diameter) of 15 to 800.

Non-Steady Flows Under Asymptotic Suction Conditions. J. H. Preston. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 4, December, 1950, pp. 435–445, illus. 3 references.

Investigation of the circulatory flow about a circular cylinder that has uniform suction applied through the surface. Approximate solutions are obtained in a closed form for the transient state that occurs when the peripheral speed of the cylinder and/or the suction is suddenly changed. The solutions are applicable to the problem of nonsteady flow past an infinite porous plate.

On the Steady Flow of Gas with Chemical Reaction. I. Heihachiro Iida. *Japan Society for Applied Mechanics, Journal*, Vol. 3, No. 19, October, 1950, pp. 150–154, illus. 5 references. In Japanese.

The increase of entropy of gas flow due to heat addition is shown to have no effect on the vorticity. From this result, a fundamental equation of motion for a perfect fluid is obtained and applied to simple flow through a distributed source of heat.

Similarity Laws for Hypersonic Flow. Klaus Oswatitsch. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 16*, July 19, 1950. 12 pp., illus. 8 references. In English.

Similarity laws are derived using shock-wave equations for the hypersonic flow region in which the free-stream Mach Number tends to infinity. Pressure coefficients and lift forces are obtained which are independent of free-stream Mach Number and, for slender bodies, proportional to the square of the thickness ratio in both plane and three-dimensional flow.

Readers' Forum: The Effect of Prandtl Number on the Theoretical Shock-Wave Thickness. Paul A. Libby. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, pp. 286, 287, illus. 1 reference.

INTERNAL FLOW

The Secondary Flow in a Cascade of Airfoils in a Nonuniform Stream. H. B. Squire and K. G. Winter. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 271–277, illus. 3 references.

A method of calculating the secondary flow in a cascade of airfoils in a stream with a variation of approach velocity along the span of the airfoils. The results are compared with measurements of the secondary flow at a cascade at a corner in a return-circuit wind tunnel where the velocity gradient is obtained as a normal consequence of flow through a diffuser. Results agree well with theory.

Method of Designing Cascade Blades with Prescribed Velocity Distributions in Compressible Potential Flows. George R. Costello. *U.S., N.A.C.A., Report No. 978*, 1950. 11 pp., illus. 6 references. Superintendent of Documents, Washington. $0.15.

Free-stream velocities of the cascade and the prescribed velocity distribution along the blade are used to obtain a suitable incompressible flow about a unit circle and the mapping function for the transformation of the incompressible flow to compressible flow about an airfoil cascade. The image of the unit circle gives the cascade having the prescribed velocity distribution along the blade. In the case of a theoretically unattainable velocity distribution, methods are given for modifying the procedure to obtain a physically significant blade shape. An isolated airfoil is considered as a special case of the cascade.

Detailed Computational Procedure for Design of Cascade Blades with Prescribed Velocity Distributions in Compressible Potential Flows. George R. Costello, Robert L. Cummings, and John T. Sinnette, Jr. *U.S., N.A.C.A., Technical Note No. 2281*, February, 1951. 49 pp., illus. 1 reference.

Influence of Wall Boundary upon the Performance of an Axial-Flow Fan Rotor. Emanuel Boxer. *U.S., N.A.C.A., Technical Note No. 2291*, February, 1951. 21 pp., illus. 3 references.

Equilibrium Operating Performance of Axial-Flow Turbojet Engines by Means of Idealized Analysis. John C. Sanders and Edward C. Chapin. *U.S., N.A.C.A., Report No. 987*, 1950. 12 pp., illus. 4 references. Superintendent of Documents, Washington. $0.15.

Simple model processes are assumed for the components of the turbojet engine. The results are plotted in terms of dimensionless parameters based on critical engine dimensions and overall operating variables in a manner that permits application of the analysis to any turbojet engine.

The Unsteady Flow of Viscous Incompressible Fluid Inside an Infinite Channel. L. Sowerby. *Philosophical Magazine*, Vol. 42 (7th Series), No. 325, February, 1951, pp. 176–187, illus. 6 references.

Analysis of the motion of a viscous incompressible fluid in an infinite wedge-shaped channel of angle π/n ($n \geq 1$); initially the channel and fluid are at rest. The velocity is obtained in terms of error functions or integrals. The heat conduction equation is solved by a Green's function. The related steady-flow problem is analyzed on the basis of Rayleigh's hypothesis for the case of the right-angled corner ($n = 2$).

Notes on the Drag of Scoops and Blunt Bodies. E. W. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13747*, April 13, 1950. 18 pp., illus. 4 references.

Evaluation of the effect of leading-edge suction on the scoop lip. For incompressible and subsonic compressible flow, the coefficient of suction (C_s) is obtained as a function of the flow ratio, assuming that the resultant drag of a scoop in uniform potential flow is zero. For supersonic flow, the scoop entrance is assumed to be located behind the normal shock in a short channel, and C_s is obtained by an approximation procedure. The appearance of drag on a blunt body is explained by an analysis of the pressure recovery behind the body.

PERFORMANCE

Performance of (Grumman) Goose 2 Aircraft. II—Aerodynamic Report. D. A. MacLulich and M. T. Friedl. *Canada, Royal Canadian Air Force, Experimental and Proving Establishment, Rockcliffe, Report No. 967* [*Final Development Report No. D104(1)-2*], January, 1951. 14 pp., illus., blueprint.

STABILITY & CONTROL

Dynamic Analysis of Aeroelastic Aircraft by Transfer Function-Fourier Method. James B. Rea. *Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950. 85 pp., illus. 17 references. Institute of the Aeronautical Sciences, Preprint No. 305. Members, $0.35; nonmembers, $0.75.

The Transfer Function-Fourier method (TFF) obtains in a single analysis (1) dynamic stability analyses of aircraft flight paths; (2) dynamic analyses of transient structural loads, especially tail loads, which arise from gust loads or maneuvering of the aircraft; and (3) flutter analysis of the aircraft control system and its multielastic structure. The aircraft is treated

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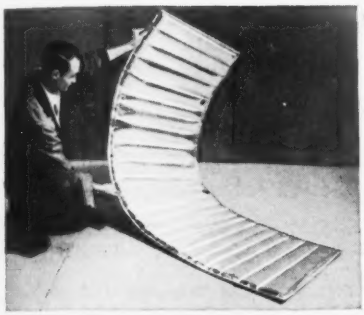

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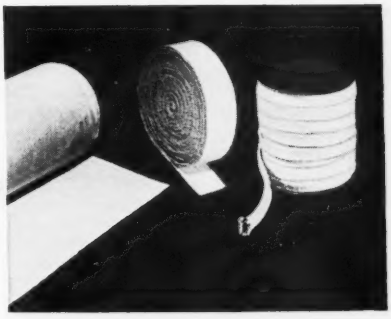

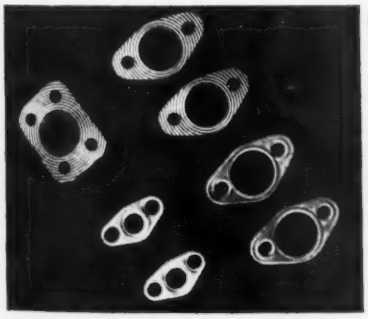

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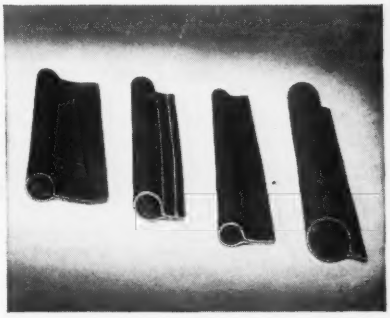

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Effects on Longitudinal Stability and Control Characteristics of a B-29 Airplane of Variations in Stick-Force and Control-Rate Characteristics Obtained Through Use of a Booster in the Elevator-Control System. Charles W. Mathews, Donald B. Talmage, and James B. Whitten. *U.S., N.A.C.A., Technical Note No. 2238*, February, 1951. 34 pp., illus. 2 references.

WINGS & AIRFOILS

Extension of the Theory of Oscillating Airfoils of Finite Span in Subsonic Compressible Flow. Eric Reissner. *U.S., N.A.C.A., Technical Note No. 2274*, February, 1951. 16 pp. 3 references.

Measurement of Downwash at a Mach Number of 1.45 Behind Two Wings of Finite Span. W. F. Hilton. *Royal Aeronautical Society, Journal*, Vol. 55, No. 481, January, 1951, pp. 43–51, illus. 4 references.

A rectangular wing and a wing with a 20° raked tip, each 3.1 per cent thick, at $M = 1.45$ and $R = 1.2 \times 10^6$ were tested in the N.P.L. 12-in. tunnel. Downwash effects were measured by a yawmeter placed 1.62 chords behind the trailing edges of the wings.

A Modification to Thin-Airfoil-Section Theory, Applicable to Arbitrary Airfoil Sections, to Account for the Effects of Thickness on the Lift Distribution. David Graham. *U.S., N.A.C.A., Technical Note No. 2298*, February, 1951. 17 pp., illus. 9 references.

Lift and Pitching Derivatives of Thin Sweptback Tapered Wings with Streamwise Tips and Subsonic Leading Edges at Supersonic Speeds. Frank S. Malvestuto, Jr., and Dorothy M. Hoover. *U.S., N.A.C.A., Technical Note No. 2294*, February, 1951. 46 pp., illus. 16 references.

Derivation of equations on the basis of linearized supersonic-flow theory, neglecting the effects of camber and thickness. Results are given in the form of generalized equations for the lift and pitching derivatives and as design curves from which the derivatives can be obtained.

Lift, Pitching Moment, and Span Load Characteristics of Wings at Low Speed As Affected by Variations of Sweep and Aspect Ratio. Edward J. Hopkins. *U.S., N.A.C.A., Technical Note No. 2284*, January, 1951. 32 pp., illus. 4 references.

Low-speed measurements of the lift, pitching moment, and pressure distribution of wings of sweepback of −40°, −30°, 0°, 35°, and 45°; aspect ratios of 6.8, 5.3, 4.2, 3.4, and 2.8; and taper ratios of 0.4 to 0.7 in the Ames 7- by 10-ft. wind tunnel.

Wind Tunnel Interference Due to Lift for Delta Wings of Small Aspect Ratio. Sune B. Berndt. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 19*, September 25, 1950. 11 pp., illus. 5 references. In English.

The air loadings on wings of small aspect ratio are calculated using the procedure of R. T. Jones. From these, the corrections are obtained for wind-tunnel interference due to lift for delta wings at small angles of attack and zero yaw.

Damping in Roll of Cruciform and Some Related Delta Wings at Supersonic Speeds. Herbert S. Ribner. *U.S., N.A.C.A., Technical Note No. 2285*, February, 1951. 43 pp., illus. 16 references. Study of cruciform and multiplanar delta wings with subsonic and supersonic leading edges.

Rotary Derivatives in Yaw. V. M. Falkner. *Aircraft Engineering*, Vol. 23, No. 264, February, 1951, pp. 44–50, 54, illus. 7 references.

Calculations have been carried out on two elliptic wings, with ratios of major to minor axis of 2.5 and 5 to 1, in order to demonstrate the use of vortex lattice theory in calculating l_r and n_r by lifting-plane theory for wings of arbitrary plan form. Special tables of downwash, required in order to allow for the curvature of the wake, are included, and the origin of the formulas by which these are derived in a form applicable to linear theory is fully explained.

Chordwise and Compressibility Corrections to Slender-Wing Theory. Harvard Lomax and Loma Sluder. *U.S., N.A.C.A., Technical Note No. 2295*, February, 1951. 44 pp., illus. 12 references.

Integral equations were developed and numerically evaluated for the corrections to slender-wing theory for the effects of compressibility and chordwise gradients in velocity for triangular and rectangular plan forms in subsonic and supersonic flow.

Supersonic Wing-Body Lift. George Morikawa. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 217–228, illus. 12 references.

Representation of lift for a fairly general family of wing-body configurations (with no afterbody) in a linearized supersonic flow over the entire range of parameters.

Air Transportation (41)

Some Meteorological Problems Indicated for Jet Transport Operation at 40,000 Ft. Henry T. Harrison. *Aeronautical Engineering Review*, Vol. 10, No. 4, April, 1951, pp. 52–61, illus. 6 references.

The Current Position of American Air Transportation. Delos W. Rentzel. *National Air Review*, February, 1951, pp. 16–22. Activities of the C.A.A. and the C.A.B. in regulating air transportation.

Where Stand Our Airlines. III. E. T. House. *Aeronautics*, Vol. 24, No. 1, February, 1951, pp. 28–40, illus., tables.

Three-year (1946–1948) evaluation and comparison of air-line economics. Data are tabulated on the operating expenses and revenues of B.O.A.C., B.E.A.C., B.S.A.A. (British South American Airways Corp.), Air France, K.L.M., T.C.A., P.A.A., and E.A.L. The effects of competition on air-line economics are analyzed.

Transporting Perishable Air Cargo. Gilbert C. Close. *Aviation Age*, Vol. 15, No. 2, February, 1951, pp. 26, 27, illus.

Lockheed Aircraft Corp.–U.S. Dept. of Agriculture research program to study the effects of air shipment on flowers and fruits, best packing methods, temperature control, and storing of perishables before and after air shipment.

Airplane Design & Description (10)

The International Civil Aviation Organization Requirements; a Review of the Development of International Airworthiness and Operational Performance Requirements. K. G. Wilkinson. *Aircraft Engineering*, Vol. 23, No. 264, February, 1951, pp. 36–39. 4 references. Tables summarize airworthiness and performance requirements for Category A airplanes (landplanes).

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Fiat G-46 Series Single-Engined General-Purpose Airplane, Italy. *Aeronautics*, Vol. 24, No. 1, February, 1951, pp. 65, 66, illus.

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Handley Page Marathon I M.60 4-Engined Transport, England (Aircraft Engineering Reference Sheet, No. 7). I, II. T. Tonkin. *Aircraft Engineering*, Vol. 23, Nos. 263, 264, January, February, 1951, pp. 15–19; 51–53; cutaway drawings.

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S.N.C.A. du Sud-Ouest SO 30 Bretagne Twin-Engined Commercial Transport, France. *Interavia*, Vol. 6, No. 1, January, 1951, pp. 13–17, 43–50, illus., cutaway drawing. Production

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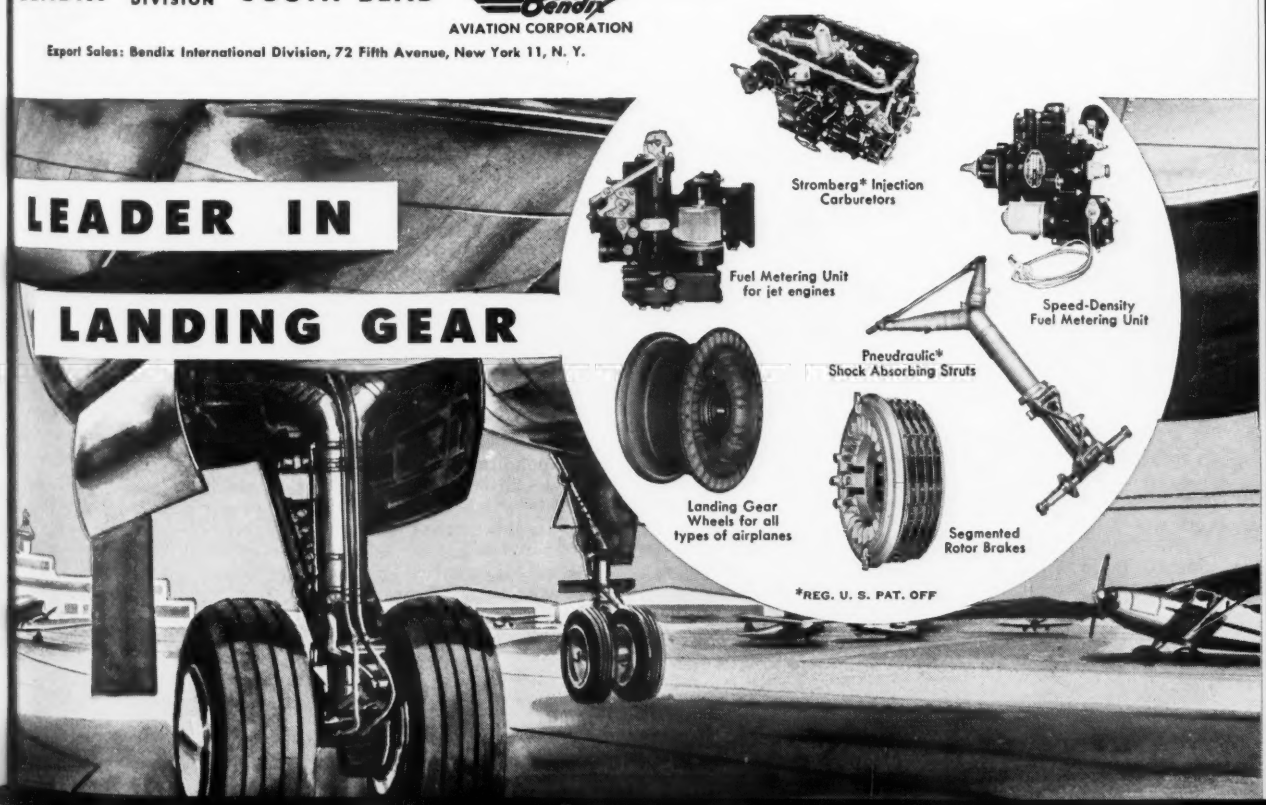
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For Safety in Controls. *Flight*, Vol. 59, No. 2194, February 8, 1951, pp. 163, illus. Methods of preventing incorrect chain-and-cable assembly.

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Germany and the Delta Wing. Alexander Lippisch. *Aero Digest*, Vol. 62, No. 2, February, 1951, pp. 30, 67, 68, 70, 71. Development of the delta wing and delta-wing rocket-powered aircraft in Germany.

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Airport Design: Its Architectural Aspects. Walther Prokosch. *Architectural Record*, Vol. 109, No. 1, January, 1951, pp. 112–118, illus. Reprint.

Northwest's Underwing Fueling Decreases Ground Service Time. E. S. Hamm. *Aviation Age*, Vol. 15, No. 2, February, 1951, pp. 30, 31, illus.

Candlepower Vs. Runway Lighting. Leslie C. Vipond. *Aviation Age*, Vol. 15, No. 2, February, 1951, pp. 34, 35, illus.

Aviation Medicine (19)

Possibility of Biological Effects of Cosmic Rays in High Altitudes, Stratosphere and Space. A. T. Krebs. *Journal of Aviation Medicine*, Vol. 21, No. 6, December, 1950, pp. 481–494, illus. 75 references.

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Electrocardiographic Response in Exercise Tolerance Tests. J. E. Smith. *Journal of Aviation Medicine*, Vol. 21, No. 6, December, 1950, pp. 470–476, illus. 10 references.

Some Engineering Aspects of the Mechanism of Body Control. Robert Mayne. *Electrical Engineering*, Vol. 70, No. 3, March, 1951, pp. 207–212, illus. 13 references.

Application of the principles of control and communications engineering to the analysis of the control of body movements. The functions of presetting, closed-loop operation, and prediction are involved.

A Modified Iodine Pentoxide Method for the Determination of Carbon Monoxide. G. A. Grant, Morris Katz, and R. L. Haines. *Canadian Journal of Technology*, Vol. 29, No. 1, January, 1951, pp. 43–50, illus. 17 references. Description of apparatus and procedure.

The Effect of Various Noise Levels on Performance of Three Mental Tasks (Psychological Studies of Training Techniques). T. D. Hanley and R. J. Williamson. (Purdue University.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 104-2-21*, December, 1950. 41 pp. 3 references.

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Automatic Control of Low Pressure Chambers. Clarence V. Pestel. *Journal of Aviation Medicine*, Vol. 21, No. 6, December, 1950, pp. 507–509, 535, illus.

A three-position manometer and a reference tank are used to control effectively the pressure in the low-pressure chambers of the Aeromedical and Physical Environment Laboratory, University of Illinois. The temperature of the reference tank is thermostatically controlled, making the system independent of barometric changes.

Comfortization (23)

Testing Aircraft Heaters. *Aircraft Heating Digest*, Vol. 2, No. 2, October, 1950, pp. 1–3, illus. Endurance and heat-balance test procedures and calculations for determining the maximum life and heat output.

Chart of Nozzle Ratings, Btu. per Hour; Specific Weight & Dynamic Pressure Charts; Table of Conversion Constants; Basic Fan Laws. *Aircraft Heating Digest*, Vol. 2, No. 2, October, 1950, pp. 6–8, illus.

Eastern Airlines Aircraft Heater Test Set-Up. I. Tony Finiels. *Aircraft Heating Digest*, Vol. 2, No. 2, October, 1950, pp. 4, 5, illus.

Education & Training (38)

A Pilot Looks at the Dehmel. D. A. Brice. *The Aeroplane*, Vol. 80, No. 2061, January 19, 1951, pp. 73–76, illus.

A pilot's evaluation of P.A.A.'s Dehmel simulator, a replica of the Stratocruiser cockpit which reproduces all the effects and situations encountered in the actual flying of the aircraft.

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Harvard 2 (Noorduyn) Standard and Armament Trainer. 1—Radio Installations. J. E. L. Renaud. *Canada, Royal Canadian Air Force, Experimental and Proving Establishment, Rockcliffe, Report No. 935 (Final Development Report No. D/154-1)*, January, 1951. 25 pp., illus., blueprint.

Elliptically Polarized Waves and Antennas. M. L. Kales and J. I. Bohnert. *U.S., Naval Research Laboratory, Washington, Report No. 3686*, June 22, 1950. 26 pp., illus. 4 references. Comprehensive and unified treatment of the theory and measurement of elliptically polarized waves and antennas.

Applications of Potential Theory to the Design of Linear Arrays. Thomas T. Taylor and John R. Whinnery. *Journal of Applied Physics*, Vol. 22, No. 1, January, 1951, pp. 19–29, illus. 11 references.

The polynomial formulation of the linear-array problem of Schelkunoff is studied from the point of view of the potential theory. The resulting electric analogy can be studied either by analytic methods or by an electronic computer. The analytic methods and their limitations are explained.

Theory of Circular Diffraction Antenna. Harold Levine and Charles H. Papas. *Journal of Applied Physics*, Vol. 22, No. 1, January, 1951, pp. 29–43, illus. 5 references.

Theoretical analysis of a circular diffraction antenna that consists of a coaxial wave guide fitted with an infinite-plane conducting baffle and which is open to free space; variational methods for calculating the circuit parameters.

Electric Dipoles in the Presence of Elliptic and Circular Cylinders. Winston S. Lucke. *Journal of Applied Physics*, Vol. 22, No. 1, January, 1951, pp. 14–19, illus. 6 references.

Application of Green's function method to the problem of the electromagnetic fields of electric dipoles in the presence of an infinitely long, perfectly conducting cylinder gives expressions for the fields in terms of an integration in the complex plane. Imposing far zone conditions leads to a simplification of the integral. Results are obtained for circular and elliptic cylinders.

Universal High-Speed Digital Computers; a Small-Scale Experimental Machine. F. C. Williams, T. Kilburn, and G. C. Tootill. (*I.E.E., Measurements Section, Paper No. 1052.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 61, February, 1951, pp. 13–28, illus. 11 references. Components and construction of the machine; automatic and manual operation; circuit diagrams.

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The Automatic Compensation of Zero-Drift Errors in Direct-Coupled Feedback Systems. F. A. Summerlin. (*I.E.E., Measurements Section, Paper No. 1088.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 61, February, 1951, pp. 59–66, illus. 6 references.

Compact Digital Differential Analyzer. *Electronics*, Vol. 24, No. 3, March, 1951, pp. 244, 246, 248, 250, 252, illus. MADDIDA, a magnetic-drum digital differential analyzer, developed by Northrop Aircraft, Inc.

An Oscilloscope for the Observation of Long Duration Transients. A. E. Ferguson. *Journal of Scientific Instruments*, Vol. 28, No. 2, February, 1951, pp. 52–56, illus.

A Precision Electronic Tachometer. S. W. Punnett and H. G. Jerrard. *Electronic Engineering*, Vol. 23, No. 276, February, 1951, pp. 55–58, illus. 6 references.

Representations of Speech Sounds and Some of Their Statistical Properties. Sze-Hou Chang, George E. Pihl, and Martin W. Essigmann. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 2, February, 1951, pp. 147–153, illus. 22 references.

Application of the Information Theory to System Design. W. G. Tuller. *Electrical Engineering*, Vol. 70, No. 2, February, 1951, pp. 124–126, illus. 2 references.

The information theory (statistical theory of communication) provides a straightforward method of evaluating a communications problem and tells directly the effect of necessary compromises from the ideal in bandwidth, power, rate of transmission, etc. The principles of the system are explained. A practical example of the application of the theory is the Private Line Air Traffic Control Communication System.

An Adjustable Temperature-Coefficient Capacitor. John A. Connor. *U.S., Naval Research Laboratory, Washington, Report No. 3689*, June 23, 1950. 10 pp., illus. 3 references.

Need for Improvement in Selenium Rectifiers. J. T. Cataldo. *Electronics*, Vol. 24, No. 3, March, 1951, pp. 182, 186, 190, 195, illus. To meet military specifications.

Semiconductor Diodes. *Electronics*, Vol. 24, No. 3, March, 1951, pp. 112, 113, illus. Summary of characteristics of silicon and germanium crystal diodes with dimensions and terminal data.

Transitor Frequency-Multiplying Circuit. W. B. Bowers. *Electronics*, Vol. 24, No. 3, March, 1951, pp. 140, 142, illus.

An electrical network for direct, rapid, and accurate multiplication of two voltages, which may go through zero, by the utilization of special characteristics of crystal triodes. The network contains no vacuum tubes or other parts that require periodic replacement.

The Electroforming of Millimeter-Wavelength Waveguide Components. Robert J. Coates and Sara F. Rogers. *U.S., Naval Research Laboratory, Washington, Report No. 3673*, June 8, 1950. 13 pp., illus. 6 references.

Statistical Evaluation of Life Expectancy of Vacuum Tubes Designed for Long-Life Expectancy. Eleanor M. McElwee. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 2, February, 1951, pp. 137–141, illus. 5 references.

Deterioration of Oxide-Coated Cathodes Under Low Duty-Factor Operation. J. F. Waymouth, Jr. *Journal of Applied Physics*, Vol. 22, No. 1, January, 1951, pp. 80–86, illus. 7 references.

The Balitron Tube. I. Norman Z. Ballantyne. *Radio & Television News*, Vol. 45, No. 3 (*Radio-Electronic Engineering*, Vol. 16, No. 3), March, 1951, pp. 16A, 17A, 20A, 30A, illus.

Design and operation of a deflection-controlled vacuum tube. The Balitron is a lens-type tube in which system arcs are used to form an arc lens system. Only a small portion of the electron beam is deflected by electrostatic means, and the deflection paths are not parallel to the path of electron acceleration.

A Parasitic FM Measurement Technique for AM Signal Generators. William E. Leavitt. *U.S., Naval Research Laboratory, Washington, Report No. 3696*, July 10, 1950. 13 pp., illus. 3 references.

A Video Pulse Counter. C. C. Watterson. *U.S., Naval Research Laboratory, Washington, Report No. 3659*, May 1, 1950. 21 pp., illus. 2 references.

Design of a pulse counter for counting discrete video pulses at a maximum rate of two megacycles per sec. and a minimum rate of 25 cycles per sec. Pulse counts are stored as capacitor charges in six cascaded decade counter stages; operation is for a crystal-controlled one-second interval. The count is presented on six panel meters, each calibrated from 0 to 9.

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A Multichannel Distance Measuring Equipment for Aircraft. E. B. Mulholland. *Australia, Commonwealth Scientific and Industrial Research Organization, Division of Radiophysics, Report No. RPR 114*, August, 1950. 36 pp., illus. 16 references.

Design and operation of a light-weight automatic Distance Measuring Equipment (DME) that provides six channels of operation. The channels are obtained by means of double-pulse selection. Block and schematic diagrams show the arrangement of the components.

Distance Measuring Equipment and Offset Course Computer. *U.S., Civil Aeronautics Administration, Airways Operations Training Bulletin No. 4*, 2nd Ed., August, 1950. 17 pp., illus. 3 references. Components, operation, and applications.

Some Recent Developments in Radio-Controlled Flight and Landing. Chester B. Watts, Jr., and Logan E. Setzer. *U.S., Civil Aeronautics Administration, Technical Development Report No. 118*, July, 1950. 22 pp., illus. 6 references.

Summary of recent progress in automatic-approach equipment; performance evaluation procedures; extension of automatic approach to touchdown; radio-controlled flight on omnirange and computer course lines.

Evaluation of 100-Channel Distance Measuring Equipment. R. C. Borden, C. C. Trout, and E. C. Williams. *U.S., Civil Aeronautics Administration, Technical Development Report No. 119*, July, 1950. 9 pp., illus. 2 references. Procedure and results of engineering and operational tests.

Automatic GCA. Joseph T. McNaney. *Electronics*, Vol. 24, No. 2, February, 1951, pp. 82–87, illus.

Simultaneous control of five aircraft spaced at two-mile intervals along a ten-mile approach corridor is provided. Azimuth, elevation, and range information are converted into phase displacements at the ground station and automatically transmitted to the plane, where information is used by autopilot to perform blind approach.

Atmospheric Noise Levels at Radio Frequencies Near Darwin, Australia. D. E. Yabsley. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 3, No. 3, September, 1950, pp. 409–416, illus. 4 references.

Signal-to-Noise Improvement by Pulse Integration. C. E. Corum. *U.S., Naval Research Laboratory, Washington Report No. 3699*, July 10, 1950. 11 pp., illus. 1 reference.

Datum Stabilizer for Radar-Altimeter Surveying. B. I. McCaffrey. *Electronics*, Vol. 24, No. 2, February, 1951, pp. 100–103, illus. 2 references.

To correct for altitude fluctuations due to turbulence when using an air-borne profile recorder, an electronic stabilizer circuit operating from an aneroid element senses deviations of aircraft from level flight and applies corrections automatically to the radar record of terrain elevation. The datum stabilizer is capable of correction for height deviations of ±200 ft. with an accuracy of ±10 ft., and up to ±250 ft. with an accuracy of ±15 ft.

A Simple Magnetic Modulator for Conversion of Millivolt D-C Signals. Gunnar Wennerberg. *Electrical Engineering*, Vol. 70, No. 2, February, 1951, pp. 144–147, illus. 16 references.

Discussion on "A Theoretical and Experimental Study of the Series-Connected Magnetic Amplifier" by H. M. Gale and P. D. Atkinson. *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 61, February, 1951, pp. 102–105, illus.

Proportional Radio Control. George R. Urquhart. *Aero Digest*, Vol. 62, No. 2, February, 1951, pp. 20, 21, 73, 74, 91, illus.

Operational principles of the proportional (positioning) radio control equipment for aircraft and guided missiles developed by Bell Aircraft Corp. Details are given of the components of the ground station and aircraft stations, and the performance of this system is compared with that of the "on-off" system.

Radio Telemetry. M. H. Nichols and L. L. Rauch. *Review of Scientific Instruments*, Vol. 22, No. 1, January, 1951, pp. 1–29, illus. 76 references.

Review and development of the underlying theory of radio telemetry to the point where it is applicable to the selection of methods that meet predetermined operating requirements and to the determination of future specifications. Since many of the principles of radio telemetry apply to air-borne recording methods, some information on air-borne recording is given. Techniques, propagation problems, antenna design, etc., are not included.

A Mechanical Model for Demonstrating Fermat's Principle. W. Cullen Moore. *American Journal of Physics*, Vol. 19, No. 1, January, 1951, pp. 1–5, illus.

Explanation of the principle of least action and description of the essential similarity between an optical system and its mechanical analog. The mechanical demonstrator was constructed for use in computing radio-propagation times for ray paths bounded by the earth and ionospheric layers.

Vertical Incidence Ionosphere Absorption at 150 Kc. A. H. Benner. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 2, February, 1951, pp. 186–190, illus. 13 references.

Effective Earth's Radius for Radiowave Propagation Beyond the Horizon. William Miller. *Journal of Applied Physics*, Vol. 22, No. 1, January, 1951, pp. 55–62, illus. 21 references.

The Waveforms of Atmospherics and the Propagation of Very Low Frequency Radio Waves (2–10 Kc.). P. W. A. Bowe. *Philosophical Magazine*, Vol. 42 (7th Series), No. 325, February, 1951, pp. 121–138, illus. 10 references.

Equipment

ELECTRICAL (16)

Discussion on "Some Problems in Aircraft Magneto Development" by R. T. Coe and D. F. Welch. *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 61, February, 1951, p. 46, illus.

Three-Relay Circuits; Tabulation of Formulas Simplifies Design and Analysis. Edward C. Varnum. *Machine Design*, Vol. 23, No. 2, February, 1951, pp. 121–124, 192, 194–196, 198, illus. 3 references.

HYDRAULIC & PNEUMATIC (20)

Development of the Unloading Gear Pump. Ernest H. Schanzlin. *Applied Hydraulics*, Vol. 4, No. 2, February, 1951, pp. 36–39, illus.

Design of a gear pump suitable for aircraft variable-volume pump-control systems. The pump is pressure loaded with oil and consists of a matched set of gears and four gear supporting bearings assembled into a close-fitting body and cover. A balanced valve controlled by the system pressure determines the unloading point. A performance curve shows the power and delivery characteristics of a typical pump.

Design of Piston Type Accumulator Uses Positive Type Pressurized "O" Seals. M. J. Phillips. *Applied Hydraulics*, Vol. 4, No. 2, February, 1951, pp. 26, 27, cutaway drawings. A design that provides a well lubricated seal with a higher sealing pressure than the existing pressures on both the gas and oil sides of the piston.

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

Ice-Proofing the J-47 Turbojet (General Electric). B. F. Morrell and N. F. Frischhertz. *SAE Journal*, Vol. 59, No. 2, February, 1951, pp. 43–47, illus. 1 reference. (Excerpts from a paper.)

Flight Safety & Rescue (15)

Flight Safety Research. V. E. Bertrandias. *Aeronautical Engineering Review*, Vol. 10, No. 4, April, 1951, pp. 31–34. (Excerpts from an address.) Functions of the U.S.A.F. Directorate of Flight Safety; safety recommendations.

The Human Factor in Aircraft Accidents. J. A. Newton. *Royal Aeronautical Society, Journal*, Vol. 55, No. 482, February, 1951, pp. 110–115.

Factors relating to pilot error as a cause of airplane crashes. The human errors that cause accidents are chiefly: error of judgment, poor technique, disobedience of orders, carelessness, and negligence. The nature and etiology of these error types are explained.

New Yardstick for Transportation Safety. Rudolph Modley. *Aviation Week*, Vol. 54, No. 6, February 5, 1951, pp. 17, 18, illus. A method for reporting transportation statistics which bases the tabulation on the loss of productive life (years) rather than on loss of life.

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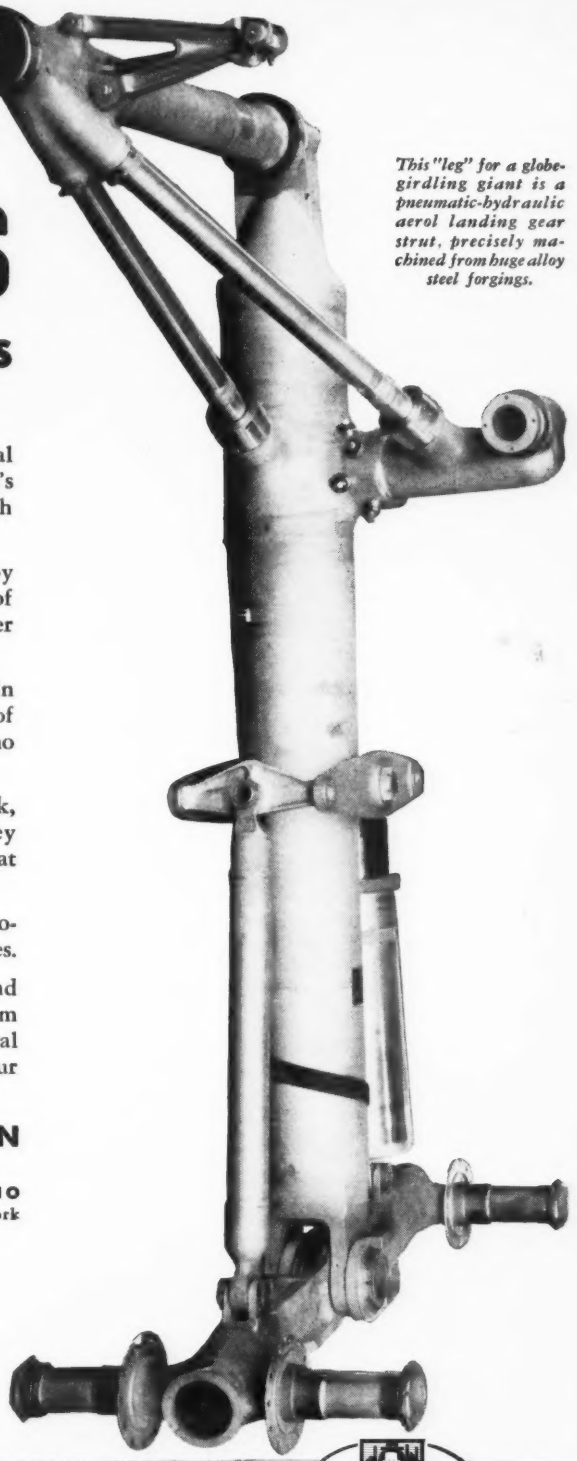

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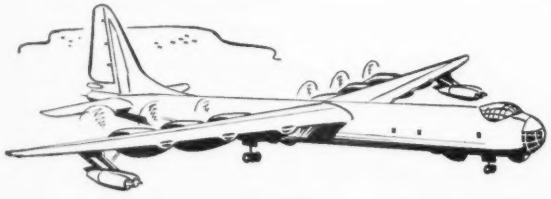

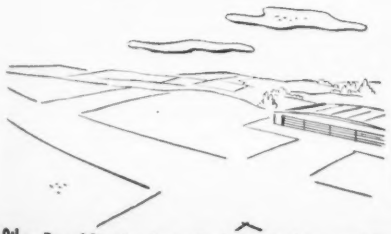

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Securing Passenger-Seats. *Flight*, Vol. 59, No. 2194, February 8, 1951, p. 150, illus. A cable-harness system to fasten aircraft seats to the floor so that they would not break away in a crash. The cables would take most of the load.

For Safety in Controls. *Flight*, Vol. 59, No. 2194, February 8, 1951, p. 163, illus. Methods of preventing incorrect chain-and-cable assembly.

A Critical Survey of Modern Practice in Combating the Fire Menace in Large Civil Aircraft. Peter J. Detmold. *The Technical Instructor*, Vol. 5, No. 12, December, 1950, pp. 3–8, illus.

The prevention of fire outbreak by thoughtful design and careful maintenance; ways of confining fires to the region of its outbreak; fire detection systems; fire extinguishing systems.

Safety Need Not Cut Down Performance. Jerome Lederer. *Aviation Week*, Vol. 54, No. 7, February 12, 1951, pp. 24–29. (Abstract of a paper.)

Fuels & Lubricants (12)

Vapor-Phase Production of Dimethylaniline. T. H. Evans and A. N. Bourns. *Canadian Journal of Technology*, Vol. 29, No. 1, January, 1951, pp. 1–18, illus. 10 references.

Investigation of the formation of dimethylaniline by vapor-phase reaction of aniline and methanol and of aniline and dimethyl ether, with activated alumina as the catalyst. Higher yields of purer dimethylaniline were obtained with aniline-dimethyl ether process.

The Oxidation, Decomposition, Ignition, and Detonation of Fuel Gases and Vapors. XVII—The Nuclear Ignition of *n*-Pentane in the C.F.R. Engine and the Effect on Performance. R. O. King, E. J. Durand, and A. B. Allan. *Canadian Journal of Technology*, Vol. 29, No. 1, January, 1951, pp. 52–60, illus. 4 references.

Fuel Testing in Gas-Turbines. K. J. Mackenzie and J. H. Boddy. *Aircraft Engineering*, Vol. 23, No. 264, February, 1951, pp. 40–42, illus. 7 references.

Investigation of the influence of water vapor (humidity) on the combustion efficiency and the combustion processes of gas-turbine fuels, including the amount of heat released, variation in burning limits with humidity, and temperature distribution in the combustion chamber and exhaust.

What Properties Should Jet Fuel Have? *Aviation Week*, Vol. 54, No. 5, January 29, 1951, pp. 26, 29, 30, 32, 37, 38, 41, 43, illus. Overall picture of the problem of setting up specifications for jet fuel; availability of fuel for expanded military operations.

Fuels for Gas-Turbine Aero-Engines. J. G. Sharp. *Aircraft Engineering*, Vol. 23, No. 263, January, 1951, pp. 2–8, illus. 1 reference.

The requirements of gas-turbine fuels based on the performance needs of engines and the problems associated with supplying the fuel from aircraft tanks to the engine combustion chambers.

Surface Chemical Phenomena in Lubrication. J. E. Brophy and W. A. Zisman. *U.S., Naval Research Laboratory, Washington, Report No. 3680*, June 20, 1950. 26 pp., illus. 49 references.

Analysis of the surface chemical phenomena encountered in lubrication: physical adsorption, chemical reactions at the solid-liquid interface, colloidal behavior of polar molecules in non-aqueous liquids, and the activity of the liquid lubricant phase as a source of, or sink for, surface active materials.

Phthalocyanine Lubricating Greases. V. G. Fitzsimmons, R. L. Merker, and C. R. Singleterry. *U.S., Naval Research Laboratory, Washington, Report No. 3672*, May 25, 1950. 21 pp., illus. 22 references.

Studies on a series of greases prepared from silicones, "Ucons," petroleums, diesters, and halocarbons gelled with 20 to 30 per cent (by weight) of phthalocyanine pigment. The chemical structure and stability of the pigments are analyzed. Tables and charts show properties of the prepared greases.

Development of a 10,000 Gallon Collapsible Container. K. R. Treiber. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 3, March, 1951, pp. 20–22, illus. A quickly erectable container for the storage of petroleum and petroleum products.

Gliders (35)

Aerodynamics of the Sailplane "Tiny Mite." August Raspet and R. H. Johnson. *Soaring*, Vol. 14, No. 10, November-December, 1950, pp. 3, 4, 10, illus. 5 references.

The Horten IV. August Raspet. *Soaring*, Vol. 14, No. 10, November-December, 1950, pp. 8, 18, illus.

The Tailless High Performance Sailplane "Horten IVb." Reimar Horten. (*Thermik*, Göttingen, No. 8–9, August 1950.) *Sailplane and Glider*, Vol. 19, No. 2, February, 1951, pp. 40–42, illus.

The Centre of Gravity Launch with Tailless Gliders. Heinz Scheidhauer. (*Thermik*, Göttingen, No. 8–9, August, 1950.) *Sailplane and Glider*, Vol. 19, No. 2, February, 1951, pp. 35, 36, illus.

The method of center of gravity launch was tested with tailless gliders in order to obtain greater release altitude. The cable pull was attached to a point considerably below the center of gravity, and a second release hook was attached to the undercarriage. The undercarriage was dropped with a small parachute after the glider was released from the tow line.

Guided Missiles (1)

A Limiting Case for Missile Rolling Moments. Ernest W. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13812*, October 23, 1950. 14 pp., illus. 4 references. A study of linearized missile rolling moments for the case of an infinite number of wings symmetrically arranged about a circular cylinder.

Project Reach. Charles De Vore. *Navigation*, Vol. 2, No. 8, December, 1950, pp. 275–281, illus.

Rocket stabilization, recovery of rocket data, instrumentation of atmospheric studies, static firing tests of the Viking. Project Reach was completed with the firing of a Viking rocket from the U.S.S. "Norton Sound," in May, 1950.

Missile Guidance. G. A. Long, Jr. *Navigation*, Vol. 2, No. 8, December, 1950, pp. 290–294, illus. 3 references. Design techniques, materials, maintenance, and operational problems of a missile guidance system; automatic navigation devices involved.

Proportional Radio Control. George R. Urquhart. *Aero Digest*, Vol. 62, No. 2, February, 1951, pp. 20, 21, 73, 74, 91, illus.

The proportional (positioning) system of radio control for aircraft and guided missiles, developed by Bell Aircraft Corp., maintains full flight control from the ground station. The proportional and the "on-off" radio control systems are compared on the bases of reliability, three-dimensional control, and recovery of the missile after landing.

Rocket Research Report No. III: Vibration in the Viking No. 3 Rocket. Lester B. Cunningham, E. E. Bissell, L. H. A. Feher, and R. W. Stroup. *U.S., Naval Research Laboratory, Washington, Report No. 3695*, July 10, 1950. 40 pp., illus.

Vibrational frequencies and amplitudes occurring in the warhead and adjacent to the rocket motor were observed during the static firing tests and during flight of the Viking No. 3 rocket. Experimental procedures and results are presented.

Instruments (9)

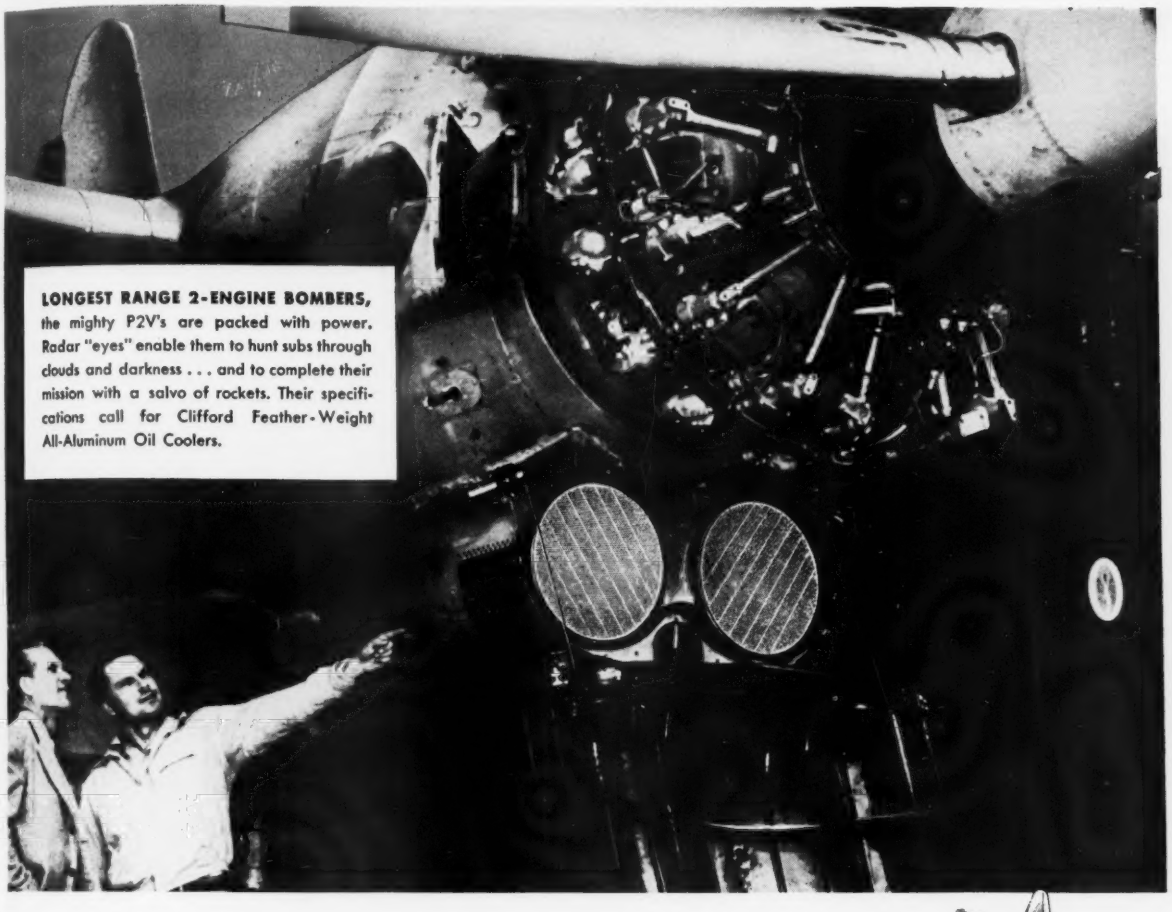
Frequency Response of Linear Systems from Transient Data. Melvin E. Laverne and Aaron S. Boksenbom. *U.S., N.A.C.A., Report No. 977*, 1950. 11 pp., illus. 5 references.

Development of a method for determining the frequency-response function of any linear system from general correlative time-response data for the input and output of the system; development of equations for system equilibrium and the effect of system dead time on the frequency-response function.

Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method. James B. Rea. *Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950. 85 pp., illus. 17 references. Institute of the Aeronautical Sciences, Preprint No. 305. Members, $0.35; nonmembers, $0.75.

In the complete dynamic analysis of aeroelastic aircraft by the Transfer Function-Fourier method (TFF) the aircraft is considered as a multiple-loop servomechanism with aerodynamic and aeroelastic feedbacks. The transient response of the system is determined by representing the input and output quantities by exponential Fourier series. The development of the TFF method in the field of automatic control is reviewed, and examples illustrate the application to the dynamic stability analysis of simple-feedback servomechanisms and automatic control systems. The matrix techniques used in flutter analysis are applicable to the dynamic analysis of systems for automatic control.

Method for Determining the Frequency-Response Characteristics of an Element or System from the System Transient Out-



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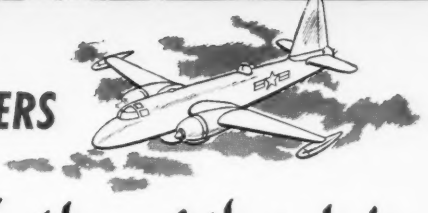

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put Response to a Known Input Function. Howard J. Curfman, Jr., and Robert A. Gardiner. *U.S., N.A.C.A., Report No. 984*, 1950. 10 pp., illus. 7 references. Superintendent of Documents, Washington. $0.15.

Stalling and the Indicator. *The Aeroplane*, Vol. 80, No. 2061, January 19, 1951, pp. 82, 83, illus. Operation of the Safe Flight stall-warning indicator.

The Development of a Turbulence Indicator for Liquids Utilizing Magnetic Induction. A. Borden. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 743*, November, 1950. 7 pp., illus. 7 references.

Theory of Kolin's electromagnetic velocity meter; specifications for a turbulence indicator; problems encountered in increasing the frequency response and sensitivity of Kolin's instrument.

An Electromagnetic Flowmeter for Transient Flow Studies. James S. Arnold. *Review of Scientific Instruments*, Vol. 22, No. 1, January, 1951, pp. 43–47, illus. 2 references. The development of an alternating-field electromagnetic flowmeter for measuring transients in liquid flows is carried out for the case of a flow channel with a rectangular cross section.

Operating Principles of Some Liquid Flow Meters. Howard W. Cole, Jr. *Product Engineering*, Vol. 22, No. 2, February, 1951, pp. 134, 135, cutaway drawings. Operating principles and accuracy of differential-pressure, variable-area, velocity-measurement, and positive-displacement types.

Parallel and Rectilinear Spring Movements. R. V. Jones. *Journal of Scientific Instruments*, Vol. 28, No. 2, February, 1951, pp. 38–41, illus.

Design of instrument movements in which the moving member is held in two equal and parallel leaf springs; development of straight-line movement through use of parallel springs; reduction of friction torque; performance evaluation.

High-Speed Direct-Trace Recording Methods. Roger Brown Loucks. *Instruments*, Vol. 24, No. 1, January, 1951, pp. 30–34, illus. 8 references.

Description of various high-speed direct-trace recording systems that do not involve photographic techniques. The systems covered are: fixed-stylus recorders coupled to electromechanical pickups, to continuously-variable pickups, to mirror galvanometers, and to cathode-ray commutator tubes and moving-stylus sweep-balance recorders.

A Frequency Compensated Direct Coupled Amplifier for Use with a Four Channel Pen Recorder. J. A. Tanner and B. G. V. Harrington. *Journal of Scientific Instruments*, Vol. 28, No. 2, February, 1951, pp. 33–35, illus. 5 references.

A direct-coupled amplifier with a balanced power stage has a voltage gain of approximately 500. Circuit diagrams of the amplifier and its components are given. The average sensitivity of the amplifier and pen recorder is 15 millivolts per mm. displacement; the response of the pen unit is flat to within ±3 per cent up to 100 cycles per sec.

Graphic Recorders with Fixed Styli. R. S. Bark. *Electronics*, Vol. 24, No. 3, March, 1951, pp. 162, 166, 170, 174, 178, 182, illus.

The Effect of Pen-to-Paper Friction in Recording Instruments. M. J. Tucker. *Electronic Engineering*, Vol. 23, No. 276, February, 1951, pp. 61–63, illus. 2 references.

A High-Pressure Differential Manometer. Martin B. Biles. *Instruments*, Vol. 24, No. 2, February, 1951, pp. 159, 204, 205, illus.

A manometer with a heavy case and tempered-glass plate "windows" that permit a direct view of the fluid columns. The instrument is suitable for pressures up to 3,000-lbs. per sq.in., which is the pressure limitation of the neoprene seals.

Servo Power Calculations. Oscar E. Carlson. *Electronics*, Vol. 24, No. 3, March, 1951, p. 134, illus. Chart of required shaft output power in watts for any combination of speed and torque of subfractional motors in tube-driven servosystems.

Closed Loop Servosystems. John D. Goodell. *Radio & Television News*, Vol. 45, No. 3 (*Radio-Electronic Engineering*, Vol. 16, No. 3), March, 1951, pp. 3A–5A, 26A, 27A, illus. Outline of basic principles in the design of servosystems emphasizing the application of servosystem concepts in attacking scientific problems.

Elimination of Brush Ripple in D.C. Tachometer-Generators Used in Servo-Mechanisms. J. C. West and T. W. Hey. *Journal of Scientific Instruments*, Vol. 28, No. 1, January, 1951, pp. 18–20, illus. 3 references.

NACA VGH Recorder. Norman R. Richardson, *U.S., N.A.C.A., Technical Note No. 2265*, February, 1951. 16 pp., illus. 1 reference.

A flight instrument for the collection of gust load data on transport aircraft which records air speed, acceleration, and altitude continuous by time periods up to 100 hours on photographic paper.

A Precision Electronic Tachometer. S. W. Punnett and H. G. Jerrard. *Electronic Engineering*, Vol. 23, No. 276, February, 1951, pp. 55–58, illus. 6 references.

Laws & Regulations (44)

High Altitude Flight and National Sovereignty. John C. Cooper. *Address delivered before the Escuela Libre de Derecho, Mexico City*, January 5, 1951. 8 pp. 1 reference. Legal aspects of high-altitude flight: does the state control the "airspace" over its land, and, if so, how far upwards does this jurisdiction extend.

Lighter-Than-Air (40)

America's Largest Blimp, the Goodyear N-1. *Interavia*, Vol. 6, No. 1, January, 1951, pp. 40–42, illus. 2 references.

Machine Elements (14)

BEARINGS

Ball Bearing Geometry; Calculating Thermal Deformations of Double-Curvature Deep-Groove Radial Bearings. Roy Krouse. *Machine Design*, Vol. 23, No. 2, February, 1951, pp. 158–162, illus.

Mounting Needle Bearings. *Bearing Engineer*, Vol. 11, No. 1, January-February, 1951, pp. 2, 3, illus.

MECHANISMS & LINKAGES

Analysis of Quadric-Chain Mechanisms. Harry Miller. *Product Engineering*, Vol. 22, No. 2, February, 1951, pp. 109–113, illus.

A method for computing the velocities and accelerations of the linkages of quadric-chain mechanisms which uses a parameter to compute accurately the values of the angles at any moment. The procedure replaces the usual graphic method.

SPRINGS

On the Stresses in Close-Coiled Helical Springs. W. M. Shepherd. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 4, December, 1950, pp. 459–468, illus. 4 references.

Maintenance (25)

The T.W.A. Overhaul and Maintenance System; A Note on Some Aspects of the Organization Developed by a Major U.S. Airline. H. W. Perry. *Aircraft Engineering*, Vol. 23, No. 263, January, 1951, pp. 22–24, 27, illus.

D-H Goblin Overhaul. *Canadian Aviation*, Vol. 24, No. 2, February, 1951, pp. 16–19, illus.

Douglas Service, Vol. 9, No. 1, January-February, 1951. 20 pp., illus. DC-3, DC-6.

Materials (8)

METALS & ALLOYS

Aircraft Metallic Materials Under Low Temperature Conditions. P. L. Teed. *Royal Aeronautical Society, Journal*, Vol. 55, No. 482, February, 1951, pp. 61–81, Discussion, pp. 81–86, illus. 20 references.

The chemical aspect; physical consequences of low temperatures; engineering significance of the effects of low temperatures; methods of lowering the transition temperatures of ferritic steels; nonferrous alloys whose impact resistance decreases with temperature.

A Metal Potential-Difference Nomogram. *Aircraft Engineering*, Vol. 23, No. 263, January, 1951, p. 29.

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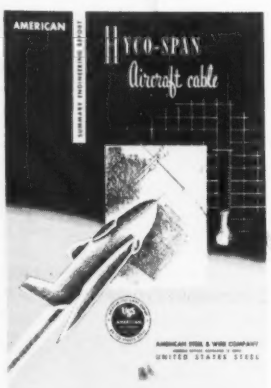

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UNITED STATES STEEL

Austenite Formation During Tempering and Its Effects on Mechanical Properties. E. F. Bailey and W. J. Harris, Jr. *U.S., Naval Research Laboratory, Washington, Report No. 3684,* June 21, 1950. 9 pp., illus. 12 references.

Mechanical-property data indicate that, if the austenite decomposes during cooling, tensile ductility and impact resistance will be decreased. If the austenite is retained, it will decrease yield strength; if it transforms during plastic deformation, it will increase tensile strength, lower elongation and reduction of area, and reduce notch toughness.

Discaloy. E. F. Losco. *Westinghouse Engineer,* Vol. 11, No. 2, March, 1951, pp. 50–53, illus. Composition, general characteristics, properties, fabrication processes of Discaloy, an alloy capable of withstanding high service temperatures and stresses.

Interpretation of Tension Creep-Time Relations. Joseph Marin and L. W. Hu. *American Society for Testing Materials, Bulletin,* No. 171, January, 1951, pp. 57–59, illus. 2 references.

Presentation of a creep-stress relation for creep of metals at elevated temperatures which is simple to use and agrees with the test data. The creep is assumed to consist of two parts that are both functions of the stress—an initial strain and a subsequent time-dependent value. Results of a number of creep-tension investigations indicate the fitness of this relation.

Exposure Tests of Galvanized-Steel-Stitched Aluminum Alloys. Fred M. Reinhart. *U.S., N.A.C.A., Technical Note No. 2299,* February, 1951. 23 pp., illus.

An investigation undertaken to determine the corrosion rates of aluminum and magnesium alloys used in aircraft after exposure to weather and in the tidewater. It is a summary of results of an investigation of the corrosion behavior of 24S-T3 and alclad 24S-T3 aluminum alloys joined to themselves by stitching with zinc-coated high-carbon steel wire.

Bearing Strengths of Some Aluminum-Alloy Permanent-Mold Castings. E. M. Finley. *U.S., N.A.C.A., Technical Note No. 2312,* February, 1951. 15 pp., illus. 2 references.

Bearing tests were made to determine bearing ultimate and yield strengths of aluminum-alloy permanent-mold castings of B-195-T4, B-195-T6, and 356-T6 and to compare the ratios of bearing to tensile properties obtained with similar data from sand-castings of like material.

Static and Fatigue Strengths of High-Strength Aluminum-Alloy Bolted Joints. E. C. Hartmann, Marshall Holt, and I. D. Eaton. *U.S., N.A.C.A., Technical Note No. 2276,* February, 1951. 61 pp., illus. 7 references. Static and fatigue tests on joints in 75S-T6, 24S-T4, and 14S-T6 extruded bar.

A Calculation of the Elastic Constants of Aluminum. R. S. Leigh. *Philosophical Magazine,* Vol. 42 (7th Series), No. 325, February, 1951, pp. 139–155, illus. 7 references.

The elastic constants are obtained as the sum of the Fermi energy and purely electrostatic energy terms of the metal during pure shear. Calculations of the shear constants in a single crystal are carried out. The manner in which the elastic constants would be expected to change with electron concentration as metals of lower or higher valence are dissolved in aluminum is demonstrated, although no experimental data are available for the confirmation of the theory.

Notes on Magnesium Alloys. I, II. F. A. Fox. *The Engineer,* Vol. 191, Nos. 4958, 4959, February 2, February 9, 1951, pp. 148–150; 180–182, illus., tables. Production; properties and behavior; extrusion; forgings; heat-treatment; fatigue characteristics; surface protection; and applications.

Titanium Rapidly Growing As Useful Engineering Material. W. T. Tiffin and P. C. Hoffman. *Materials & Methods,* Vol. 33, No. 2, February, 1951, pp. 57–59, illus. 4 references.

Rolling of Strip from Iron Powder. G. Naeser and F. Zirm. (*Stahl und Eisen,* Vol. 70, No. 22, October, 1950, pp. 995–1004.) *The Engineer's Digest,* Vol. 12, No. 1, January, 1951, pp. 17–20, illus. 5 references.

Powdered iron or steel is compressed, passed between two horizontal rolls by friction to form a continuous strip, and sintered. The resulting strip is of uniform thickness and density. Repeated rolling and annealing improve the properties of the strip.

NONMETALLIC MATERIALS

Strength of Orthotropic Materials Subjected to Combined Stresses. Charles B. Norris. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1816,* July, 1950. 48 pp., illus. 25 references.

Development of a theory of the strength of orthotropic materials subjected to combined stresses. Equations that agree with test data are developed for the relations between the strength of orthotropic materials subjected to a single stress and the natura axes of the material.

Metal-to-Metal Bonding for Aircraft Structures; Claims of the Redux Process. *Flight,* Vol. 59, No. 2194, February 8, 1951, pp. 169–171, illus.

Strength of Heat-Resistant Laminates up to 375°C. B. M. Axilrod and Martha A. Sherman. *U.S., N.A.C.A., Technical Note No. 2266,* February, 1951. 57 pp., illus. 17 references. Results of flexural tests on glass-fabric laminates.

Effect of Prestressing in Tension or Compression on the Mechanical Properties of Two Glass-Fabric-Base Plastic Laminates. Fred Werren. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1811,* September, 1950. 33 pp., illus. 4 references. Results of 36 tension and 45 compression tests.

Reinforced Plastics. Richard J. Francis. *Product Engineering,* Vol. 22, No. 2, February, 1951, pp. 85–108, illus. Types; molding and fabricating; properties and design factors in selection and use; industrial and consumer applications.

New Silicone Elastomer (Silastic 250) Retains Properties over Wide Temperature Range. *Materials & Methods,* Vol. 33, No. 1, January, 1951, pp. 67, 68, illus.

List of Publications on Mechanical Properties and Structural Uses of Wood and Wood Products. *U.S., Forest Products Laboratory, Madison, Wis., Report No. R200 Revised,* August, 1950. 48 pp.

A list of 463 publications that contain general information and the results of research by the U.S. Forest Service on the strength of timbers and factors affecting strength; design of wood articles or parts where strength or resistance to external forces is important. References are grouped chronologically under 54 subject headings, and the author and source are given for each item.

SANDWICH MATERIALS

Elastic Constants for Corrugated-Core Sandwich Plates. Charles Libove and Ralph E. Hubka. *U.S., N.A.C.A., Technical Note No. 2289,* February, 1951. 105 pp., illus. 6 references.

Presentation of formulas for evaluating the elastic constants of a corrugated-core sandwich plate of either the symmetric or unsymmetric type. The formulas are limited to plates that are not subject to local buckling. The formulas for three of the elastic constants have been checked experimentally, and test results agree well with theory.

Short-Column Compressive Strength of Sandwich Constructions As Affected by the Size of the Cells of Honeycomb-Core Materials. C. B. Norris and W. J. Kommers. *U.S., Forest Products Laboratory, Madison, Wis., Report No. 1817,* August, 1950. 24 pp., illus. 3 references. Tests on sandwich specimens with wood cores and 24 ST clad aluminum facings.

Elastic and Plastic Buckling of Simply Supported Solid-Core Sandwich Plates in Compression. Paul Seide and Elbridge Z. Stowell. *U.S., N.A.C.A., Report No. 967,* 1950. 10 pp., illus. 5 references. Superintendent of Documents, Washington. $0.15.

Finite Deflections of Curved Sandwich Plates and Sandwich Cylinders. F. K. Teichmann and Chi-Teh Wang. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Fund, Paper No. FF-4,* January, 1951. 9 pp., illus. 8 references. Members, $0.50; nonmembers, $0.85.

A finite deflection theory for cylindrical sandwich elements may be required under certain conditions that depend primarily upon the rigidity of the core material. There are indications that, as the shear rigidity of the core is increased, nonlinear effects become important, as in the case of the homogeneous shell. Accordingly, the equilibrium differential equations are formulated, and the corresponding stress-displacement relationships are derived for use in further theoretical developments.

Elements of Sandwich Construction. S. K. Ghaswala. *Institution of Engineers, India, Journal,* Vol. 31, No. 1, September, 1950, pp. 47–62, illus. 28 references. Reprint.

A "Solid-Guide Fixture" for Determining the Properties of Thin Sheet Material in Compression. J. H. Rondeel and G. C. Duyn. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. S. 368,* May 27, 1950. 15 pp., illus. 3 references. Design of an instrument to determine the properties of thin sheet metal in compression. Results are plotted of tests made on steel and alclad specimens.

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Electron Microscopy of Metal Samples by Replica Techniques. L. S. Birks and R. T. Seal. *U.S., Naval Research Laboratory, Washington, Report No. 3693,* June 15, 1950. 9 pp., illus.

Microhardness Tester for Metals at Elevated Temperatures. Abner Brenner. *U.S., National Bureau of Standards, Journal of Research,* Vol. 46, No. 2, February, 1951, pp. 126–131, illus. 7 references. (Also available as *Research Paper No. 2185.* Superintendent of Documents, Washington. $0.10.)

Design and operation of a tester for measuring the hardness of electrodeposited coatings at temperatures up to 900°C. in an inert atmosphere. The instrument consists of a Vicker's diamond on a shaft of fused silica. The load on the indenter ranges from 25 to 1,000 grams.

An Evaluation of the Effective Gage-Length Equivalent of the Fillet and Shoulder of the Gage-Length Portion of a Tension Test Bar Under Creep and Stress-Rupture Conditions. H. V. Kinsey. *American Society for Testing Materials, Bulletin,* No. 171, January, 1951, pp. 60–62, illus. 4 references. For measurements of metals at high temperatures.

Nondestructive Testing of Engineering Materials and Parts (Materials & Methods Manual No. 67). R. C. McMaster and S. A. Wenk. *Materials & Methods,* Vol. 33, No. 2, February, 1951, pp. 81–96, illus.

Meteorology (30)

Tables of Precipitable Water and Other Factors for a Saturated Pseudo-Adiabatic Atmosphere. *U.S., Weather Bureau, Technical Paper No. 14,* 1951. 27 pp., tables.

Mean Monthly and Annual Evaporation from Free Water Surface from the United States, Alaska, Hawaii, and West Indies. *U.S., Weather Bureau, Technical Paper No. 13,* July, 1950. 10 pp., tables.

Jet Streams: Effect on Flight Planning. Ron Yates. *Wings,* Vol. 6, No. 3, December, 1950, pp. 14, 15, illus. 2 references.

An Unusual Radiosonde Flight at Lander, Wyoming, Indicating Large Vertical Motions. DeVer Colson. *American Meteorological Society, Bulletin,* Vol. 31, No. 10, December, 1950, pp. 371–374, illus. 7 references.

Gusts—from a Clear Sky. G. S. Hislop. *Aircraft,* Vol. 29, No. 3, December, 1950, pp. 18, 19, 40, 41, illus. Investigation of the problem of high-altitude gusts in clear air by the British European Airways' Clear Air Gust Research Project.

Variation of Upper Air Temperature with Season and Latitude. *Meteorological Magazine,* Vol. 79, No. 941, pp. 314–321, tables.

Progress in Meteorological Instrumentation, 1920–1950. Athelstan F. Spilhaus. *American Meteorological Society, Bulletin,* Vol. 31, No. 10, December, 1950, pp. 358–364. 44 references.

A Simple Form of Sensitive Electric Contact Cup Anemometer. S. G. Crawford. *Journal of Scientific Instruments,* Vol. 28, No. 2, February, 1951, pp. 36, 37, illus. 2 references.

The counter mechanism of the cup anemometer is replaced with a make-and-break electric contact to obtain a reliable record of mean wind speed with a 6-volt battery and a low-resistance message register. The counter can operate up to a maximum wind speed of 20 meters per sec. The calibration is almost linear.

A Synoptic Study of Instability Lines. Marion E. Crawford. *American Meteorological Society, Bulletin,* Vol. 31, No. 10, December, 1950, pp. 351–357, illus. 7 references.

Some Meteorological Problems Indicated for Jet Transport Operation at 40,000 Ft. Henry T. Harrison. *Aeronautical Engineering Review,* Vol. 10, No. 4, April, 1951, pp. 52–61, illus. 6 references. Thunderstorm and gust research at high altitudes.

Upper Atmosphere Research Report No. XI: a Note on the Geometry of Geiger Counter Telescopes. Homer E. Newell, Jr., and Eleanor C. Pressly. *U.S., Naval Research Laboratory, Washington, Report No. 3715,* August 8, 1950. 9 pp., illus. 2 references.

Navigation (29)

Motion Relative to the Surface of the Rotating Earth. Ralph Hoyt Bacon. *American Journal of Physics,* Vol. 19, No. 1, January, 1951, pp. 52–56, illus. 3 references.

Wind in Rectangular Co-Ordinates. Robert Ashton. *Guild of Air Pilots and Air Navigators, Journal,* Vol. 10, No. 5-6, October–December, 1950, pp. 27, 28, illus.

Astro-Fix by Ranges. Oliver C. Collins. *Institute of Navigation, Journal,* Vol. 4, No. 1, January, 1951, pp. 20–30, illus. 4 references.

Two methods by which lines of position may be obtained by observation of stars (in pairs) without the use of instrumental scale readings either for altitude or for azimuth. These lines of position represent arcs of great circles of the earth. An instantaneous observation is proposed.

The Selection of Stars for Astronomical Navigation. D. H. Sadler. *Institute of Navigation, Journal,* Vol. 4, No. 1, January, 1951, pp. 31–33.

A table of 57 selected stars showing number, constellation name, proper name, magnitude, and approximate position, which are adequate for all purposes of air navigation and for almost all surface navigation.

Navigation and the Aircraft Industry. Robert Watson-Watt. *Institute of Navigation, Journal,* Vol. 4, No. 1, January, 1951, pp. 1–11. Overall picture of approach and landing aids and navigation systems.

An Investigation into Air Traffic Control by a Simulation Method. R. B. Coulson and V. D. Burgmann. *Institute of Navigation, Journal,* Vol. 4, No. 1, January, 1951, pp. 34–65, illus. 11 references.

Investigation of air-traffic-control systems in Australia; simulation equipment; control systems tested with this equipment; theory of airport congestion; radio-range approach studies; analysis of the orbiting approach system; control by defined stacking; control system using Multiple Tract Range (MTR) and Distance Measuring Equipment (DME); statistical analysis of traffic-control problems when arrival times are not random.

The Decca Flight Log Pictorial Presentation. C. Powell. *Shell Aviation News,* No. 151, January, 1951, pp. 14–19, illus.

Schuler Tuning Characteristics in Navigational Instruments. Walter Wrigley. *Navigation,* Vol. 2, No. 8, December, 1950, pp. 282–290, illus. 9 references.

Schuler tuning is defined as the condition of minimizing the error in a gyrocompass (or in any pendulum) by tuning the natural period of oscillation of the pendulum in the earth's gravity to approximately 84 min. The physical basis of Schuler tuning is explained. Equations and explanations are given for Schuler tuning in a simple pendulum, a physical pendulum, a gyropendulum, and a gyrocompass.

Diagrammatic Solutions for Astronomical Navigation. H. C. Freiesleben. *Institute of Navigation, Journal,* Vol. 4, No. 1, January, 1951, pp. 12–19, illus. 8 references.

Description of the ARG I astronomical computing instrument and the Astronomical Calculation Atlas, which are German methods of using diagrammatic solutions for accurate astronomical navigation.

Ordnance & Armament (22)

Fighter Armament. VII—Simple Rocket Versus Guided Missile—and Some General Conclusions. A. R. Weyl. *Flight,* Vol. 59, No. 2192, January 25, 1951, pp. 108–110, illus.

Power Plants

Atomic-Powered Aircraft Propulsion. A. Kalitinsky. *The Aeroplane,* Vol. 80, No. 2064, February 9, 1951, pp. 172, 173, 176, 177, illus. (Excerpts from a paper.)

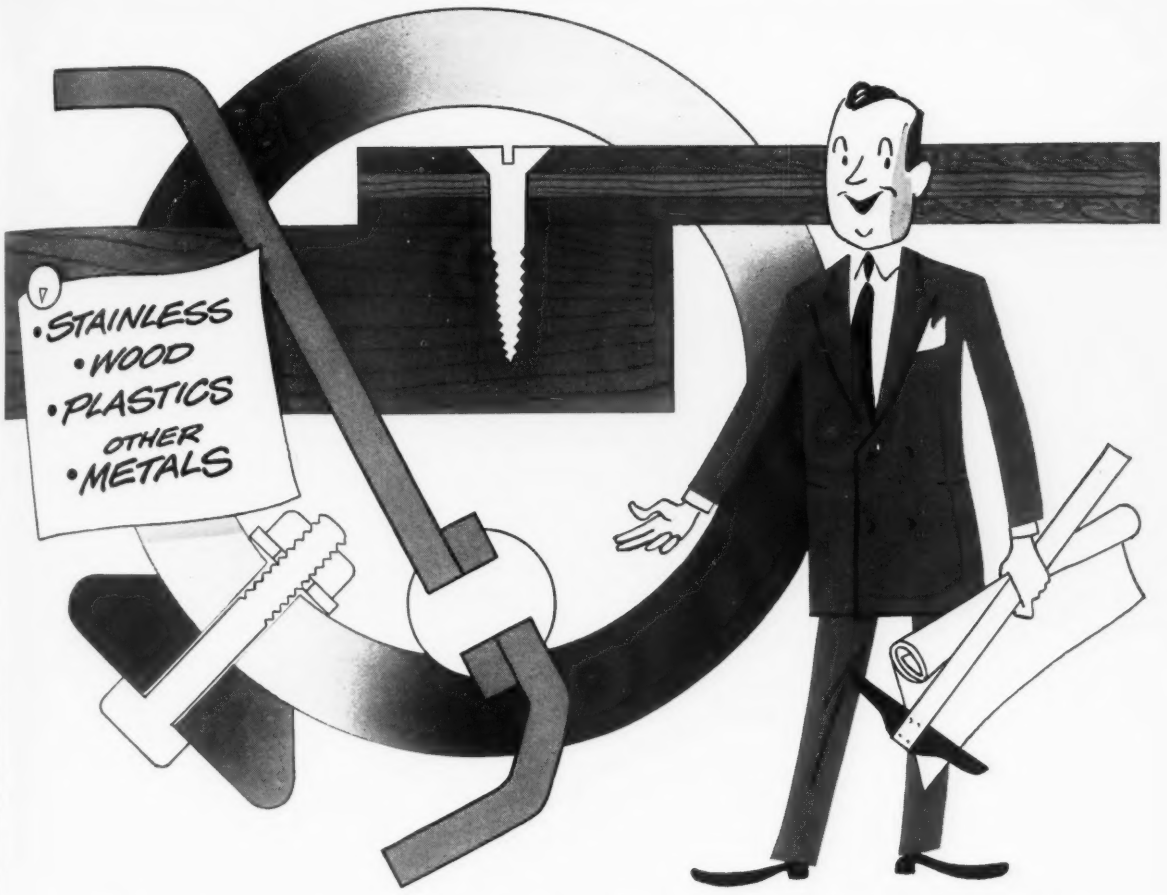
JET & TURBINE (5)

Turboprops' Challenge to Turbojets. Paul H. Wilkinson. *Aviation Age,* Vol. 15, No. 2, February, 1951, pp. 36, 37, illus.

Current turboprop engines are grouped according to their power outputs. Engines in each class are compared with jet and piston engines of similar power output. A table gives data on the turboprops in production and under development, 1950—1951.

Fuel Testing in Gas-Turbines. K. J. Mackenzie and J. H. Boddy. *Aircraft Engineering,* Vol. 23, No. 264, February, 1951, pp. 40–42, illus. 7 references.

Calculation of the variation of combustion-chamber efficiencies and air mass flow due to the presence of water vapor (humidity). Correction factors are computed and plotted against specific humidity for the variation of air mass flow for the orifice meters and Pitot-static tubes used in combustion-chamber tests. Correction factors are also obtained for the combustion-chamber efficiency and outlet temperature distribution.



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Armstrong-Siddeley Adder A.S.A.1 Turbojet. *Flight*, Vol. 59, No. 2195, February 15, 1951, pp. 187–190, illus., cutaway drawings.

Successful Trials of a Ducted Fan. *The Aeroplane*, 80, No. 2064, February 9, 1951, pp. 170, 171, illus. The Aspin 1 gas-turbine unit, produced by the French Turboméca Co., with a dual-flow air system.

A Reducing Valve Development. *The Aeroplane*, Vol. 80, No. 2060, January 12, 1951, p. 57, illus.

A nitrogen reducing valve for an aircraft fuel system which reduces, in one stage, the gas pressure from about 1,800 lbs. per sq.in. to 0.5 lb. per sq.in. The valve, developed by Varley Pumps and Engineering, Ltd., is effective down to gas temperatures of −3 °C.

Starters for Turbojet Engines. William D. Downs. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 2, February, 1951, pp. 14–18, illus. 3 references.

Turbine engines require starter assistance up to about 20 per cent or more of rated engine speed, a requirement that has resulted in the development of air and cartridge-type starters Each type is described, and its performance is evaluated. Curves compare the effective horsepower for the starter types and give the overall weight for various engine installations.

Gas Turbine Installation. H. W. Sidwell. *Hawker Siddeley Review*, Vol. 3, No. 4, December, 1950, pp. 13–18, illus. Problems encountered in installing a gas-turbine engine in a flying test bed; testing procedures.

Turbine Blade Fastenings; A Review of Early and Modern Designs. Harold Woodhouse. *Machine Design*, Vol. 23, No. 2, February, 1951, pp. 148–153, illus

Free and Forced Vibrations of Rotating Blades. Robert Plunkett. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 278–282, illus. 14 references.

Development of the matrix equations governing transverse vibration of a rotating twisted cantilever beam, such as a propeller or a turbine blade, from which the vibration in natural frequency with rotational speed can be determined. This analysis is applied to the forced vibrations of a blade due to oscillating loading.

RECIPROCATING (6)

Air Force Development of an Air-Cooled Supercharged, Lightweight Multifuel Diesel Engine. M. E. Davis and F. J. Neugebauer. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 3, March, 1951, pp. 15–20, illus. 1 reference.

Development of a two-cylinder Diesel engine that can operate on fuels ranging from common Diesel oil through 100-octane aviation gasoline. This development is part of an Air Force project to design a compact air compressor for aircraft maintenance and servicing. The engine is of simple construction, has low weight and high displacement, and is suitable for arctic operations.

Development and Performance of Aero-Engine Fuel Injection Systems. A. R. Griffin. *Shell Aviation News*, No. 151, January, 1951, pp. 20–24, illus.

Results of development work on port and direct cylinder fuel-injection systems as applied to a variety of full-scale, single-cylinder aircraft engines. The design requirements of the two methods of injection and their potentialities are assessed.

Tests Reveal Best Gaps for Aircraft Spark Plugs. C. E. Swanson and J. W. Miller. *SAE Journal*, Vol. 59, No. 2, February, 1951, pp. 32–35, illus. (Excerpts from a paper.) Experimental investigation to determine the maximum permissible gaps for aircraft-engine spark plugs under various operating conditions.

Turbo-Supercharging. *Flight*, Vol. 59, No. 2194, February 8, 1951, pp. 153, 154, illus., cutaway drawings. Operation of the General Electric CH 9 turbosupercharger for use with the Pratt & Whitney R-4360 Wasp Major engines.

ROCKET (4)

Application of Rocket Power to Aircraft. Howard R. Moles. *Aeronautical Engineering Review*, Vol. 10, No. 4, April, 1951, pp. 24–30, illus. Liquid-propellant rockets for manned aircraft; power-plant characteristics; propellants; advantages of rocket-powered aircraft.

Rockets and Assisted Take-Off. A. V. Cleaver. *Royal Aeronautical Society, Journal*, Vol. 55, No. 482, February, 1951, pp. 87–102, Discussion, pp. 102–109, illus. 4 references. Rocket-motor design; fuel composition, performance, and economy; problems in the proper selection of a rocket and its fuel for practical use.

Production (36)

Engineering Developments in Production Processes. T. E. Piper. *Western Flying*, Vol. 31, No. 2, February, 1951, pp. 12–14, 33, illus. (Excerpts from a paper.) Factors affecting production engineering methods, processes, and tools; uses of plastics; forming machines; welding; controls.

Metal-Stitching; A Review of the Possibilities of the Process; Strength-Characteristics and Applications. C. A. H. Pollitt. *Aircraft Production*, Vol. 13, No. 148, February, 1951, pp. 62–64, illus.

West Coast Metalworking Progress in 1950. Thomas A. Dickinson. *Steel Processing*, Vol. 37, No. 1, January, 1951, pp. 20–22, 43, 49, illus.

Installation of Hufford stretch-forming machines at North American Aviation, Inc., for sheet-metal fabrication and modern welding equipment at Boeing Airplane Co.; low-melt alloys and high-strength plastics were used as casting compounds for mold and die fabrication at Convair.

Simplified Die Making Through Standardization. Ralph L. Weisbeck. *Aero Digest*, Vol. 62, No. 2, February, 1951, pp. 42, 66, illus. The Wales Multiple Hole Punching System, for round-hole perforating, uses standardized punch and die elements completely interchangeable within their respective hole ranges. The assembly is self-contained, thus eliminating all die setting.

Magnesium Assembly Methods. *Magazine of Magnesium*, February, 1951, pp. 8–11, illus.

Procedures Used in Precision-Casting Foundry. William F. Davenport and Adolph Strott. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 2, February, 1951, pp. 19–23, illus.

Preparation of soft-metal dies for wax casting; the wax injection process; precoating the pattern; and firing the mold. The alumina-silica precoat gave a smooth oxide-free surface on high chromium-content alloys. Precoats containing varying proportions of silica flour and alumina were tested to determine the optimum precoating material.

Using the Cecostamp for Impact Forming Sheet Metal Parts for Aircraft Production. R. B. Stubbs. *Aviation Age*, Vol. 15, No. 2, February, 1951, pp. 40–45, illus.

Wood Tooling; Specialist Manufacture of Tools for Rubber-Die and Stretch-Forming; Composite Stretching Tools for Anti-Icing Panels. *Aircraft Production*, Vol. 13, No. 148, February, 1951, pp. 35–37, illus.

Honing; Use of Higher-Power Equipment for Fast Stock-Removal. E. D. Ball. *Aircraft Production*, Vol. 13, No. 148, February, 1951, pp. 51, 52, illus.

Squeeze-Riveting; Equipment for Flush-Riveted Fuselage-Skin Panels for the Bristol Type 175 Aircraft. *Aircraft Production*, Vol. 13, No. 148, February, 1951, pp. 41–48, illus.

The Welding of Aluminum Alloys, Particularly for Structural Applications. W. K. B. Marshall. *Institute of Welding, Transactions*, Vol. 13, No. 6, December, 1950, pp. 178–185, illus. 12 references.

Easy Buying. James Joseph. *Aero Digest*, Vol. 62, No. 2, February, 1951, pp. 19, 83, 85, 87, illus. The use of automatic business machines (punch-card techniques) in inventory and purchasing control at Douglas Aircraft.

Machine-Load Planning; Application of Remington Rand Sched-U-Graph System to the Control of Production Processes. *Aircraft Production*, Vol. 13, No. 148, pp. 38–40, illus.

Production Engineering, Administration and Management. VIII. J. V. Connolly. *Aircraft Engineering*, Vol. 23, No. 263, January, 1951, pp. 19–21. 5 references.

Design Economics; Analysis and Co-Ordination of Material and Manufacturing Costs (at The Glenn L. Martin Company). John Van Hamersveld. *Aircraft Production*, Vol. 13, No. 148, February, 1951, pp. 53–59, illus.

Cost Control Engineering. I—Organization and Functions. John Van Hamersveld. *Machine Design*, Vol. 23, No. 2, February, 1951, pp. 108–114, illus. Functions of the consulting group of design cost-control engineers at The Glenn L. Martin Co.

EEMCO technical bulletin

Unconventional Hydraulic Pump Motor Saves Weight... Increases Efficiency

Hydraulic pump motors normally operate through a reduction to achieve pump speeds of 3 - 4000 R.P.M. Illustrated at the left is a new motor designed for high-speed pumps which requires no such reduction. Developed by EEMCO in cooperation with the designers and builders of leading aircraft, this motor was designed for an allowable pump speed of 7200 R.P.M. The motor mounts directly on the pump with an internal spline drive within the armature shaft providing the coupling.

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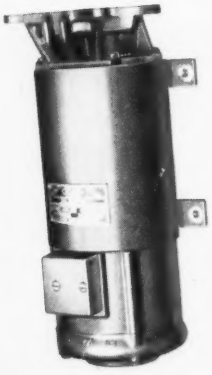

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Propellers (11)

Tests of Two-Blade Propellers in the Langley 8-Foot High-Speed Tunnel to Determine the Effect on Propeller Performance of a Modification of Inboard Pitch Distribution. James B. Delano and Melvin M. Carmel. *U.S., N.A.C.A., Technical Note No. 2268*, February, 1951. 67 pp., illus. 5 references.

Free and Forced Vibrations of Rotating Blades. Robert Plunkett. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 278–282, illus. 14 references.

Development of the matrix equations governing transverse vibration of a rotating twisted cantilever beam, such as a propeller or a turbine blade, from which the vibration in natural frequency with rotational speed can be determined. This analysis is applied to the forced vibration of a blade due to oscillating loading.

Reference Works (47)

BIBLIOGRAPHIES

A Bibliography of Rotating Wing Aircraft. A. J. Bennett and R. N. Liptrot. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 3, October–December, 1950, pp. 118–133.

A list of 281 items covering all published work considered valuable from the historical, theoretical, or practical engineering point of view. The material is presented in chronological order under 12 classified headings.

YEARBOOKS

Inventory of Air Power. *Aviation Week*, Vol. 54, No. 9, February 26, 1951. 206 pp., illus.

Survey of U.S. aviation industry—military, manufacturing, research, personal flying, airports, guided missiles, electronics, helicopters, lighter-than-air craft, and air transport; foreign air power—mobilization, civilian production, and military aircraft. Engine and aircraft specifications and photographs are included.

Rotating Wing Aircraft (34)

Helicopter Design. Robert McLarren. *Aero Digest*, Vol. 62, No. 2, February, 1951, pp. 75–82, 84, illus. Review of helicopter design progress; engineering problems; a chronology of helicopter development.

The Helicopter. III—Present and Future Uses of Rotating-Wing Aircraft; Trends in Design. R. N. Liptrot. *Flight*, Vol. 59, No. 2191, January 18, 1951, pp. 78–82, illus.

A Bibliography of Rotating Wing Aircraft. A. J. Bennett and R. N. Liptrot. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 3, October–December, 1950, pp. 118–133.

A list of 281 items covering all published work considered valuable from the historical, theoretical, or practical engineering point of view. The material is presented in chronological order under 12 classified headings.

Airworthiness Requirements and Fatigue of Helicopters. J. Shapiro. *Aircraft Engineering*, Vol. 23, No. 264, February, 1951, pp. 32–35, 54, illus. Some unconventional and controversial reflections on the true significance of failures and how to avoid them.

Hiller's $5,000 Helicopter. Howard Waldorf. *Flying*, Vol. 48, No. 3, March, 1951, pp. 17, 62, illus.

The Hiller Hornet, a twin ram-jet, two-place, two-control helicopter with a cruising speed of 70 m.p.h., a climbing speed of 1,100 f.p.m., and a ceiling of 11,000 ft. Cruising range is approximately 50 miles.

Helicopter Maintenance. Maintenance As It Affects the Regular Scheduled Operator. E. A. Voss. **Helicopter Maintenance for the Non-Regular Schedule Operator.** Alan E. Bristow. **General Problems of Helicopter Maintenance.** J. Leason. *The Technical Instructor*, Vol. 6, No. 1, January, 1951, pp. 3–12, Discussion, pp. 12–15, illus.

Helicopter Maintenance. E. A. Voss. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 2, July–September, 1950, pp. 50–55, Discussion, pp. 67–76, illus. Details of the "progressive maintenance system" developed by B.E.A.

Helicopter Maintenance for the Non-Regular Schedule Operator. Alan E. Bristow. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 2, July–September, 1950, pp. 56–62, Discussion, pp. 67–76. Maintaining the Hiller 360 for commercial operations.

General Problems of Helicopter Maintenance. J. Leason. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 2, July–September, 1950, pp. 63–67, Discussion, pp. 67–76. The problems from the standpoint of the maintenance engineer; the need for improved test procedures and maintenance manuals is stressed.

Helicopter Maintenance. Accessibility, Servicing, and Testing of Components. G. E. Walker. **An Analysis of Present-Day Helicopter Maintenance.** F. L. Swain. **Materials and Fatigue Aspect.** W. E. Cooper. *Helicopter Association of Great Britain, Journal*, Vol. 4, No. 3, October–December, 1950, pp. 85–103, Discussion, pp. 104–117, illus.

Some Operational Problems of Public Transport Helicopters. R. H. Whitby. *Royal Aeronautical Society, Journal*, Vol. 55, No. 481, January, 1951, pp. 27–42, illus. 11 references.

The progress of, and requirements for, night and blind flying, navigation, and landing approach under instrument conditions. The requirements for safe operation to and from restricted locations are considered in view of enabling helicopter transport service to approach the regularity of fixed-wing aircraft service.

Ramjets Power Hornet Helicopter; Tiny Hiller Craft, Using Two Basic Combined Methods, Shows Excellent Flight Performance. *Aviation Week*, Vol. 54, No. 8, February 19, 1951, p. 25, illus.

Effects of Compressibility on the Performance of Two Full-Scale Helicopter Rotors. Paul J. Carpenter. *U.S., N.A.C.A., Technical Note No. 2277*, January, 1951. 17 pp., illus. 5 references. Tests on twisted and untwisted rotor blades in the Langley helicopter test tower at tip speeds of 350–770 ft per sec. to obtain stall and compressibility data.

Sciences, General (33)

MATHEMATICS

Dynamic Analysis of Aeroelastic Aircraft by Transfer Function-Fourier Method. James B. Rea. *Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950. 85 pp., illus. 17 references. Institute of the Aeronautical Sciences, Preprint No. 305. Members, $0.35; nonmembers, $0.75.

The Transfer Function-Fourier (TFF) method obtains, in a single analysis, flight-path stability, dynamic tail loads, and flutter response of an aircraft by treating the aircraft as a servomechanism. The concept of the transfer function and the application of Fourier techniques are explained. In determining the transient response of the system, the input and output are represented by the exponential form of Fourier series. Common I.B.M. matrix-multiplication techniques are a convenient and practical tabulating method. The Log Modulus Control Method (developed by Brown and Campbell) is used for multiplying and dividing the transfer functions. TFF is easily adapted to automatic computation methods.

Estimation of the Errors of the Least-Squares Polynomial Coefficients. P. G. Guest. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 3, No. 3, September, 1950, pp. 364–375, illus. 4 references.

Using the Ordinary Slide Rule to Reciprocate Complex Numbers. William A. Edson. *Journal of Engineering Education*, Vol. 41, No. 5, January, 1951, pp. 336, 337, illus.

Universal High-Speed Digital Computers; A Small-Scale Experimental Machine. F. C. Williams, T. Kilburn, and G. C. Tootill. (*I.E.E., Measurements Section, Paper No. 1052.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 61, February, 1951, pp. 13–28, illus. 11 references. A computer that uses the serial binary-digital system of number representation.

A Mechanical Model for Demonstrating Fermat's Principle. W. Cullen Moore. *American Journal of Physics*, Vol. 19, No. 1, January, 1951, pp. 1–5, illus.

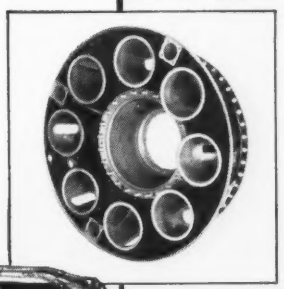
Application of the theory of least action to mechanical systems, electric circuits, and ray optics; explanation of the similarity between an optical system and its mechanical analog.

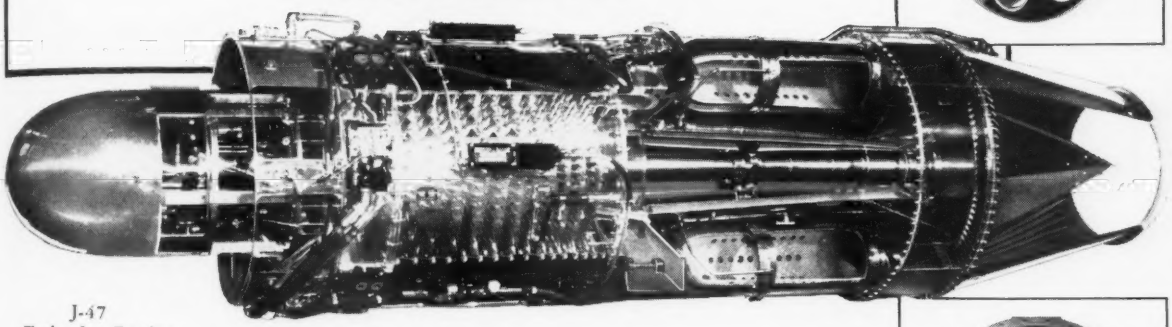
Compact Digital Differential Analyzer. *Electronics*, Vol. 24, No. 3, March, 1951, pp. 244, 246, 248, 250, 252, illus.

MADDIDA, a magnetic-drum, digital differential analyzer developed by Northrop Aircraft, Inc., for the solution of linear and

JET ENGINES and COMPONENTS by FAIRCHILD

Rear Frame





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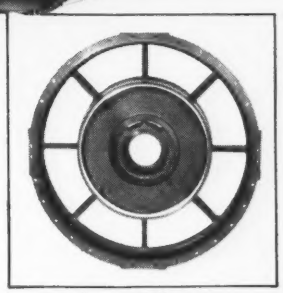
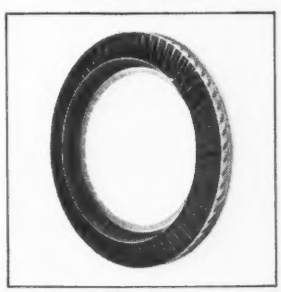
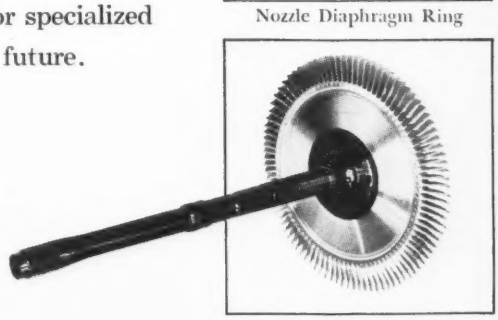


Forward Frame



Nozzle Diaphragm Ring



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nonlinear differential equations of any order or degree, integral equations, transcendental algebraic equations, and simultaneous sets of such equations.

New Brains on the Job. Louis R. Huber. *Boeing Magazine*, Vol. 21, No. 2, February, 1951, pp. 11–13, illus. Boeing's electronic analog computer.

A Device for Computing Correlation Functions. A. E. Hastings and J. E. Meade. *U.S., Naval Research Laboratory, Washington, Report No. 3679*, June 16, 1950. 5 pp., illus. 3 references.

Analog computer for autocorrelation functions and the cross-correlation of two different functions. The computer handles Fourier transforms obtained from a sample of time functions by a mechanical wave analyzer or by computation.

Proposed Design of the NRL Electronic Digital Computer. D. H. Gridley and B. L. Sarahan. *U.S., Naval Research Laboratory, Washington, Report No. 3714*, July 18, 1950. 15 pp., illus. 1 reference.

Design details of a general purpose, high-speed, electronic digital computer (NAREC) of the parallel type, which will perform addition, subtraction, multiplication, and division with binary numbers of 44-digit precision at the rate of 9,000 operations per sec. The computer will handle the reduction of experimental data, solution of systems of linear equations with a large number of unknowns, nonlinear differential equations, and similar complex problems. Memory facilities are an electrostatic storage for 1,024 words and a magnetic-drum storage for 2,048 words.

Machined "Math" Saves Man-Hours. Franklin Myers. *The Martin Star*, Vol. 10, No. 2, February, 1951, pp. 10, 11, 15, illus.

Operations of the Automatic Computing Section of The Glenn L. Martin Co. This section uses I.B.M. punched-card machines (the calculating punch and the Card-Programmed Calculator), the Reeves Electronic Analogue Computer (REAC), and telecomputing equipment for aerodynamic and structural calculations.

Application of Potential Theory to the Design of Linear Arrays. Thomas T. Taylor and John R. Whinnery. *Journal of Applied Physics*, Vol. 22, No. 1, January, 1951, pp. 19–29, illus. 11 references.

Mathematical and electric analogy theory underlying an electric analog computer for the synthesis of arrays to produce a desired radiation pattern and for the evaluation of existing arrays. The procedure is based on the polynomial formulation of the linear array problem.

A Simple Analogue Computer for Fourier Analysis and Synthesis. J. H. Bowen and T. E. Burnup. *Electronic Engineering*, Vol. 23, No. 276, February, 1951, pp. 67–69, illus. 3 references.

Theory, general circuit arrangements, and operating details of an analog computer with an expected accuracy of ± 5 per cent of the maximum reading.

An Improved Electrical Network for Determining the Eigenvalues and Eigenvectors of a Real Symmetric Matrix. Abraham Many. *Review of Scientific Instruments*, Vol. 21, No. 12, December, 1950, pp. 972–974, illus. 1 reference.

The network, capable of solving matrices up to the tenth order, has an eigenvalue accuracy of 0.01 per cent of the difference between the greatest and smallest values and an eigenvector accuracy of more than 1 per cent of the greatest component. The eigenvalues are given by the resonance frequencies of the network, and the components of the eigenvectors are given by the voltages across the coils.

On the Application of Dimensional Analysis. S. F. Borg. *American Journal of Physics*, Vol. 19, No. 2, February, 1951, pp. 69–73. 5 references.

Presentation of a method of dimensional reasoning which is based on tensor invariants and on a postulated form of certain equations in applied mechanics. The differential equations of some of the invariant equations may be obtained qualitatively by a consideration of the characteristic tensors in the field under investigation. The procedure is applied to equations appearing in problems of elasticity, fluid mechanics, vibration, and loadings on plates and shells.

Bounds for Characteristic Roots of Matrices. II. Olga Taussky. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 2, February, 1951, pp. 124, 125. 4 references. (Also available as *Research Paper No. 2184*. Superintendent of Documents, Washington. $0.05.) Bounds of characteristic roots of matrices with positive (nonnegative) elements; bounds for multiple roots.

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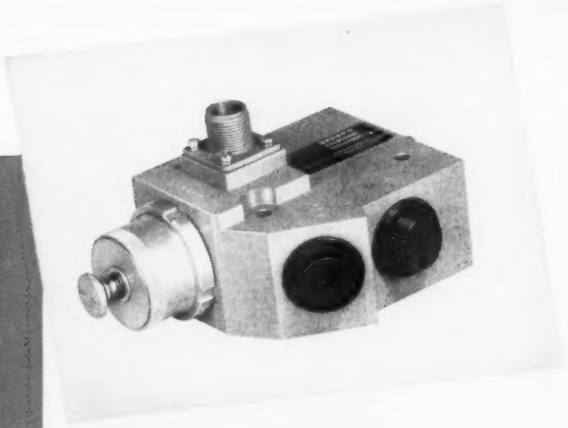

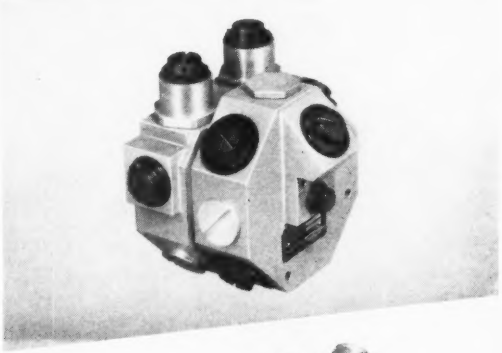

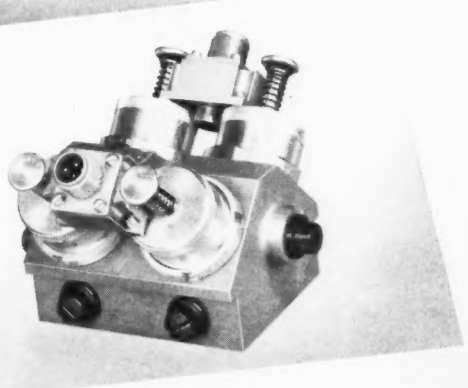

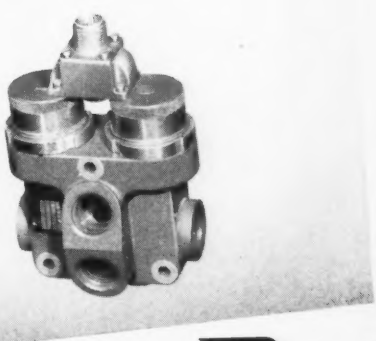

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1/2" T.S. 4-Way Selector Valve	Cylinder Ports Connected to Return in Neutral with Solenoid De-Energized. Manual Over-Ride.	550690	1.75 Lb.
3/4" T.S. 4-Way Selector Valve	Cylinder Ports Connected to Return in Neutral with Solenoid De-Energized. Manual Over-Ride.	550700	3.1 Lb.
3/8" T.S. 4-Way Selector Valve	Cylinder Ports Connected to Return in Neutral with Solenoid De-Energized. No Manual Over-Ride.	548690	1.75 Lb.
1/2" T.S. 4-Way Selector Valve	Cylinder Ports Connected to Return in Neutral with Solenoid De-Energized. No Manual Over-Ride.	548570	1.75 Lb.
3/4" T.S. 4-Way Selector Valve	Cylinder Ports Connected to Return in Neutral with Solenoid De-Energized. No Manual Over-Ride.	548710	3.1 Lb.
3/8" T.S. 4-Way Selector Valve	Cylinder Ports Blocked to Return in Neutral with Solenoid De-Energized. No Manual Over-Ride.	551210	2.0 Lb.
1/2" T.S. 4-Way Selector Valve	Cylinder Ports Blocked to Return in Neutral with Solenoid De-Energized. Manual Over-Ride.	550800	2.0 Lb.
3/8" T.S. 3-Way Selector Valve	Cylinder Port Connected to Return in Neutral with Solenoid De-Energized. Manual Over-Ride.	550660	1.6 Lb.
5/8" T.S. 3-Way Selector Valve	Cylinder Port Connected to Return in Neutral with Solenoid De-Energized. Manual Over-Ride.	550585	2.2 Lb.
5/8" T.S. 3-Way Selector Valve	Cylinder Port Blocked to Return in Neutral with Solenoid De-Energized.	550630	2.2 Lb.
1/4" T.S. Dual Bank 4-Way Selector Valve	Cylinder Ports Connected to Return with Solenoid De-Energized. Manual Over-Ride.	550640	2.8 Lb.

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On the Vibratory Characteristics in the System Having a Small Clearance. I. Kichiji Nishino. *Japan Society for Applied Mechanics, Journal*, Vol. 3, No. 19, October, 1950, pp. 145–149, illus. 5 references. In Japanese. The nature of the subharmonic resonance in the system is studied by expressing the restoring force in the form of a fifth-degree curve of displacement.

Space Travel

Rocket Navigation. Samuel Herrick. *Navigation*, Vol. 2, No. 8, December, 1950, pp. 259–272, illus.

The celestial mechanics systems of Ptolemy, Copernicus, Kepler, and Galileo are briefly reviewed as a basis for the computation of rocket trajectories in space. The two-body problem is used to explain the establishment of a satellite orbit (around the earth) and the orbit for a trip to Venus or Mars. The interplanetary trajectories are, essentially, geocentric rectilinear orbits in the initial phase, heliocentric ellipses in the intermediate phase, and planetocentric rectilinear orbits in the final phase. The application of "three-body" and the "special perturbation" procedures are explained. A table of constants and calculation procedure are presented for computing rocket trajectories based on two-body analysis.

Instruments for Upper Atmosphere and Interplanetary Navigation. John C. Bellamy. *Navigation*, Vol. 2, No. 8, December, 1950, pp. 272–275. Conditions of operation; limitations of present aircraft navigational instruments; possible future instruments.

Structures (7)

Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method. James B. Rea. *Douglas Aircraft Company, Inc., Report No. SM-13868*, July 13, 1950. 85 pp., illus. 17 references. Institute of the Aeronautical Sciences, Preprint No. 305. Members, $0.35; nonmembers, $0.75.

The Transfer Function-Fourier method (TFF) provides, in a single analysis, the complete rigid-body and aeroelastic analysis of an aircraft. An aeroelastic aircraft is analyzed dynamically by treating it as a multiple-loop servomechanism with aerodynamic and aeroelastic feedbacks. A clear picture of the true physical nature of the system is provided; the response data can be readily checked by dynamic flight-test techniques. Examples demonstrate the applicability of the TFF method to actual aircraft dynamic analysis, including the effects of tail and gust loads.

Note on the Distortion Characteristics of Swept and Cranked Wings in Relation to Flutter and Other Aeroelastic Phenomena. D. Williams. *Royal Aeronautical Society, Journal*, Vol. 55, No. 482, February, 1951, pp. 116–125, illus. 3 references.

The parts played by calculation and by resonance tests on simplified scale models in obtaining the normal modes of an airplane with wings of unorthodox plan forms are discussed on the basis that the normal modes are the best means of defining the elastic-inertia characteristics of an aircraft for the purpose of flutter investigations.

The Characteristics of Systems Which Are Nearly in a State of Neutral Static Stability. W. J. Duncan. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 4, December, 1950, pp. 452–458. 2 references.

What Does the Theory of Plasticity Offer to the Designer? William Prager. *The Trend in Engineering*, Vol. 3, No. 1, January, 1951, pp. 8–12, illus.

The mechanical concepts of the theory of plasticity which influence design practices are presented in an elementary manner. The effect of plastic loading of the structure is explained graphically and in a greatly simplified mathematical manner.

Lateral Elastic Instability of Hat-Section Stringers Under Compressive Load. Stanley Goodman. *U.S., N.A.C.A., Technical Note No. 2272*, January, 1951. 35 pp., illus. 2 references.

The buckling loads for five stringers are computed over a range of lengths by a conventional strain-energy method that employs two arbitrary constants in the deflection equations. An equation having five arbitrary constants is derived and used to compute the buckling loads for various lengths of one of the five stringers.

On the Torsion of a Circular Rod of Non-Uniform Diameter. Yuzo Nakagawa. *Japan Society for Applied Mechanics, Journal*, Vol. 3, No. 19, October, 1950, pp. 154–157, illus. 3 references. In Japanese. Supplement to an earlier study in which a nonhomogeneous material was assumed, and a general solution expressed by Legendre's associated functions was obtained.

Design Factors for Stress Concentration. I—Notches and Grooves in Bending. R. E. Peterson. *Machine Design*, Vol. 23, No. 2, February, 1951, pp. 169–173, illus. 9 references.

Data sheets give stress-concentration factors in graphic form; the application of the data sheets is explained. Data are given for the cases of notches, grooves, fillets, and transverse holes subjected to axial bending or torsional loading.

An Investigation of Pure Bending in the Plastic Range When Loads Are Not Parallel to a Principal Plane. Harry A. Williams. *U.S., N.A.C.A., Technical Note No. 2287*, February, 1951. 61 pp., illus. 6 references. Tests of rectangular and I-beams of 75S-0 aluminum alloy with the plane of loading at angles of 0°, 30°, 60°, and 90° to the minor principal axis of the cross section.

A Method for Calculating Stresses in Torsion-Box Covers with Cutouts. Richard Rosecrans. *U.S., N.A.C.A., Technical Note No. 2290*, February, 1951. 38 pp., illus. 3 references.

The method of analysis is based on an idealization of the cover in which the uncut portion is represented by three stringers that carry all direct stresses; all the shear is carried by the webs and cover sheets. Expressions are developed for the shear and direct stress in terms of the torque distribution between the shear webs and cover sheets in the cutout. The actual torque distribution is computed by use of the principle of least work, thus giving actual shear and direct stresses. Differential equations of equilibrium are derived for the computation of the stresses along each stringer.

Moment of Resistance of Beams Stressed Beyond the Elastic Limit. M. Ish Horowicz. *Aircraft Engineering*, Vol. 23, No. 263, January, 1951, pp. 9–14, illus. 43 references.

Presentation of a method for predicting the moments of resistance of beams, subjected to pure bending beyond the limit of proportionality, which applies to all types of sections and materials that have different stress-strain properties in tension and compression. The calculations involve only simple mathematical expressions and give a high degree of accuracy.

Studies on the Buckling of Riveted Thin Plates. Tomio Kubo. *Japan Society for Applied Mechanics, Journal*, Vol. 3, No. 19, October, 1950, pp. 157–167, illus. 8 references. In Japanese.

The theoretical values of the buckling load between rivets, the buckling load of the entire system, the effective width, and the ultimate strength of riveted thin plates were obtained as functions of rivet spacing, rivet diameter, the number of plates, and the combination of plate thicknesses. Theoretical results were verified by experiments that included determination of the slipping factors of the rivets.

Basic Differential Equations in General Theory of Elastic Shells. V. S. Vlasov. (*Prikladnaia Matematika i Mekhanika*, Moscow, Vol. 8, 1944, pp. 109–140.) *U.S., N.A.C.A., Technical Memorandum No. 1241*, February, 1951. 58 pp., illus. 13 references.

Readers' Forum: Calculation of Deflections in Indeterminate Structures. H. F. Michielsen. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, pp. 284, 285.

Readers' Forum: The Calculation of Deflection in Indeterminate Structures. Bruno A. Boley and Roland H. Moore. *Journal of the Aeronautical Sciences*, Vol. 18, No. 4, April, 1951, p. 285. 3 references.

The Determination of Critical Loads by Energy Methods. M. D. Brisby. *The Engineer*, Vol. 191, No. 4956, January 19, 1951, pp. 82–84, illus.

Formulas, based on energy considerations, are given for the computation of critical loads in buckling, bending, and compression of elastic systems. Several practical examples illustrate the application of the method.

Isolated Force Problems in Two-Dimensional Elasticity. II. M. Rothman. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 4, December, 1950, pp. 469–480, illus. 1 reference.

Solution of the problem of several isolated forces in equilibrium on the boundary of discs of certain shapes by Stevenson's complex potential method.

(*Continued on page 166*)

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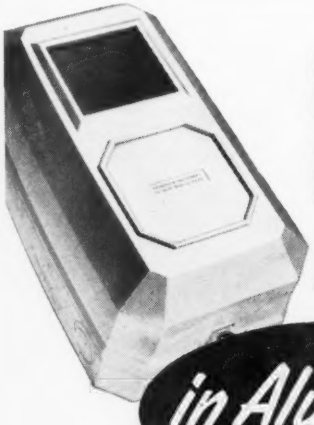

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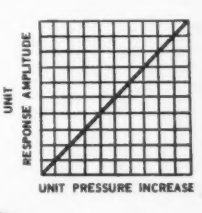

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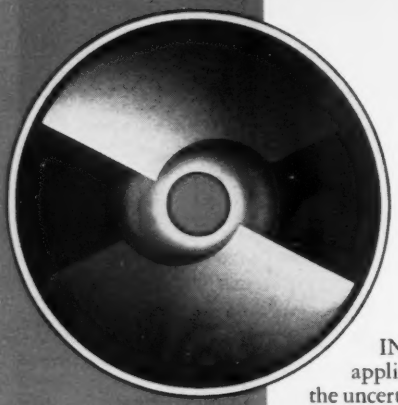

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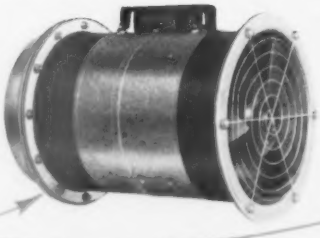
MODEL #M141C-1A

(1 stage.) 27 volt DC. Boeing 377 Stratocruiser condenser cooler, 2 per airplane. 3,700 CFM at 4" Total Head Pressure. Totally Explosion Proof. Wt. 49 lbs.

MODEL #M8862F-9A

(2 stage.) 27 volt DC. Special modification of M8862B-8B. Performance identical. Martin 202 Airliner ground heating and cooling. Wt. 35 lbs.

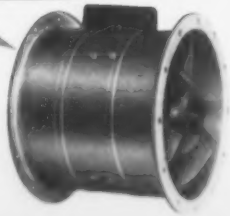


MODEL #M8922A-9A

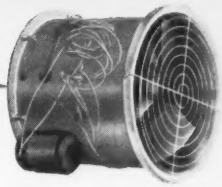
(2 stage.) 27 volt DC. Special modification of M8862B-8B. 1,785 CFM at 8" or 1,560 CFM at 10" Static Pressure. American Airlines CV 240 cooling of refrigeration aftercooler. Wt. 36 lbs.

MODEL #M8921A-1A

(1 stage.) 27 volt DC. Special adaptation from M8862B-8B for Navy P2V airplane. 1,200 CFM at 6" Static Pressure. Wt. 21 lbs. Other information restricted.



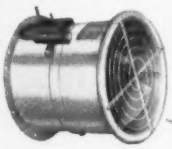
MODEL #M7861L-1B (1 stage.) 115 volt, 60 cps, AC. Used by several Electronics Mfrs. for tube cooling. 450 CFM at .5" Static Pressure. Wt. 9 lbs.



MODEL #M7861N-2A
(1 stage.) 115 volt, 60 cps, AC. Identical to M7861K-1B except for configuration.

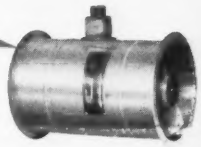
MODEL #M5862X-9A
(2 stage) 27 Volt DC, 450 CFM at 7" H_2O. Used on several aircraft for recirculation, heat. & vent. systems and equipment cooling. Wt. 10 lbs.

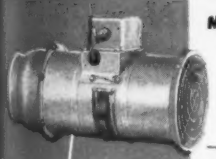
MODEL #M5861AD-8A
(1 stage.) 27 volt DC. Stewart-Warner USAF Glider Packaged Heater Unit. 340 CFM at 5" Static Pressure. Wt. 7¼ lbs.



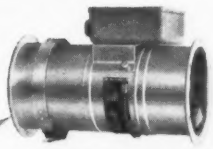
MODEL #M5861B-2A
(1 stage) 27 Volt DC, 400 CFM at 2.7" H_2O. Available in several modified configurations and for 400 cps current. Wt. 5½ lbs.

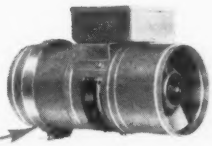
MODEL #M5862Q-1A
(2 stage) 27 Volt DC, 400 CFM at 5.5" H_2O. Available also for 400 cps current. Wt. 9 lbs.





MODEL #M4582AD-2A
(2 stage.) 27 volt DC. NAA B-45 airplane. 225 CFM at 6" Static Pressure. Wt. 9 lbs.



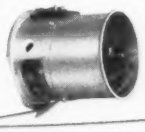


MODEL #M4582B-6A
(2 stage.) 27 volt DC. Constellation 649, 749 & 1049 flt. deck booster, heat. & vent. 300 CFM at 4" Static Pressure. Wt. 8.75 lbs.

MODEL #M4582B-1C1
(2 stage.) 27 volt DC. 377 Stratocruiser generator cooling. 4 per airplane. 275 CFM at 5" Static Pressure. Wt. 8.75 lbs.

MODEL #M4581A-3A
(1 stage.) 27 volt DC. & 400 cps AC. Constellation 649 and 749 defoggers. Westinghouse and General Electric and others for electronic tube cooling. This blower also made for 400 cps AC current. 145 CFM at 1.5" Static Pressure. Wt. 4.2 lbs.

MODEL #M4581A-2B
(1 stage.) 27 volt DC. & 400 cps AC. Same as M4581A-3A except for housing configueration.



MODEL #M4581A-2BA
(1 stage.) 27 volt DC. Special modification of housing for Westinghouse Electronics. Otherwise same as M4581A-2B.

MODEL #M4381B-1B
(1 stage.) 27 volt DC. & 400 cps AC. Westinghouse and Bendix electronic cooling, several models. 110 CFM at .4" Static Pressure. Wt. 1.75 lbs.

MODEL #M4381B-1C
(1 stage.) 27 volt DC. & 400 cps AC. Modification of M4381B-1B to plastic special shape housing. 90 CFM at .4" Static Pressure. Wt. 1.40 lbs.

MODEL #M2881A-1
(1 stage.) 27 volt DC. & 400 cps AC .Used on numerous electronic installations for tube cooling. 60 CFM unrestricted. 36 CFM at .80" S.P. Wt. 1¼ lbs.

MODEL #M2881A-2A
(1 stage.) 27 volt DC., cps & 400 cps AC. This model can be modified with several types of housing and for several types of current. It can also be built in "two-stage" to double the pressure characteristic. 1 stage performance 60 CFM at .2" or 35 CFM at .8". Wt. 1¼ to 2 lbs. depending on modification.

MODEL #M2881F-3
(1 stage.) 27 volt DC. permanent magnet motor. 60 CFM at .2" or 30 CFM at .5" S.P. Wt. 8 oz.

MODEL #M2881F-8A
(1 stage.) Same as other M2881 units. Shown here for type of housing.

MODEL #M1921N-1
(1 stage.) 27 volt DC. or 400 cps AC. 32 CFM at .2" or 20 CFM at .5" S.P. Wt. 7½ oz.

MODEL #M1921N-1A
Same as M1921N-1 except housing.

MODEL #M1921P-6A
(1 stage) 400 cps single or 3-phase. Available in numerous housing configurations. 15 CFM at .15" H_2O. Wt. 14 ounces.

These small 2" diameter blowers can be made in any of a number of housing configurations to suit tight space limitations.

Pictures shown here are actual photographs of only a portion of the active models available and are intended to show the numerous configurations available. All data subject to change without notice.

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Aeronautical Reviews — BOOKS

Airplane Aerodynamics

By Daniel O. Dommasch, Sydney S. Sherby, and Thomas F. Connolly. New York, Pitman Publishing Corporation, 1951. 520 pp., diagrs. $6.50.

Like many other textbooks, *Airplane Aerodynamics* had its origin in notes prepared for lecture courses. At times, this can be a serious handicap to the general usefulness of the book, either as a general text or as a reference work, but, in this case, full advantage appears to have been taken of exceptional opportunities to make a real contribution to the art and science of aeronautics.

It is perhaps indicative of the trend of the times that the present text is the work of a well-balanced "team." Each of the three coauthors has been able to bring to bear a thorough knowledge of one or more major specialties involved, combined with a clear understanding of the needs of both the student and the instructor. The authors set for themselves a definite goal, effectively stated in the preface:

"This book is designed with the fundamental purpose of creating an understanding of the 'how' and 'why' of modern aerodynamics. It is designed for students having a background in college physics, mathematics, calculus, mechanics and dynamics. It is not a treatise on mathematical methods, nor a handbook, but the mathematical approach is used as necessary to insure proper understanding, and sufficient practical data are supplied to insure an integrated picture."

The scope of the treatment is perhaps best indicated by listing the 16 chapter headings, as follows:

1, The Atmosphere. 2, Fundamental Dynamics and Thermodynamics of Air. 3, Types of Fluid Flow. 4, Airfoil Theory. 5, Wing Theory. 6, Drag. 7, The Propeller. 8, Aircraft Propulsion. 9, The Basic Performance Problem. 10, Special Performance Problems. 11, Maneuvers. 12, Theory and Design of Control Surfaces. 13, Introduction to Stability and Control. 14, Longitudinal Stability and Control. 15, Lateral and Directional Stability and Control. 16, Seaplane Problems.

The treatment is remarkable for its completeness and its clarity on every page. There are many explanatory sketches and diagrams that are most helpful in achieving that clarity, and there is always ample evidence that the authors not only know their subject but also appreciate fully the exact spots where the student needs special assistance in grasping the full significance of important relations. The fact that the book was originally written for a test-pilot school turns out to be a distinct advantage rather than a handicap. Emphasis is always placed on those points that experience has shown to be most important in the understanding of the problems of airplane operation. The overall result is a textbook of exceptional merit. It seems to have unlimited possibilities as the basic text in any course of aeronautical engineering.

In addition to its primary use as a text, *Airplane Aerodynamics* should be extremely valuable to all aeronautical engineers as a reference work. It has an excellent index, and the answers to many questions can be readily found.

The authors are to be congratulated on the excellence with which they have achieved their "fundamental purpose of creating an understanding of the 'how' and the 'why' of modern aerodynamics."

CAPT. WALTER S. DIEHL, U.S.N.
Bureau of Aeronautics

Aerodynamics of Supersonic Flight

By Alan Pope. New York, Pitman Publishing Corporation, 1950. 185 pp., illus., diagrs. $4.00.

The appearance of Alan Pope's *Aerodynamics of Supersonic Flight* vividly illustrates the need for a critical review of undergraduate aeronautical curricula.

It has become apparent that, in order to meet the demands of industry, graduate engineers must be familiar with transonic and supersonic phenomena. Nevertheless, for the most part, college programs have remained static in a period of overwhelming change. However, one of the strongest arguments for the inclusion of an undergraduate course in supersonics is given by the book presently under discussion.

Professor Pope will be remembered for his *Wind Tunnel Testing*, which has become the only universally accepted text on this subject. Like its predecessor, his latest book combines lucidity of presentation with practicality of coverage. In addition to providing a one-term introduction to the field of supersonics, it will be useful to those engineers who did not study high-speed flight in college, and, because each section is self-explanatory, it may even serve as a source of readily available knowledge. Prerequisites for reading need only be differential and integral calculus and an understanding of elementary aerodynamics.

There are three outstanding sections in the text. The first is an unusually clear depiction of the effect of back-pressure changes on the flow through a nozzle. The treatment here is both qualitative and quantitative and eventually encompasses shock reflections, design of nozzles by the method of characteristics, flow of jets emanating from nozzles, and various boundary-layer effects.

The second section, as might be expected, is a treatise on supersonic wind tunnels and testing devices. Here, the author describes, at some length, the various types of testing facilities and expounds on the advantages and peculiarities of each. Noise, condensation, dust, and heating and cooling problems are discussed. Diffuser design and shock stability, along with model testing procedure, are treated. Ballistic nomenclature is introduced. The paragraphs on the optical visualization methods are concise but pertinent. Finally, a review of the vistas opened by other testing means—i.e., missiles, rocket carriages, water tables, and whirling arms—is also included. In short, this chapter presents a broad picture.

The third section of unusual interest concerns itself with three-dimensional wing theory. In particular, the mechanism of drag-rise delay with sweepback is covered as well as the theoretical occurrence and variation of form-drag peaks with maximum thickness position for delta plan forms. It is found ad-

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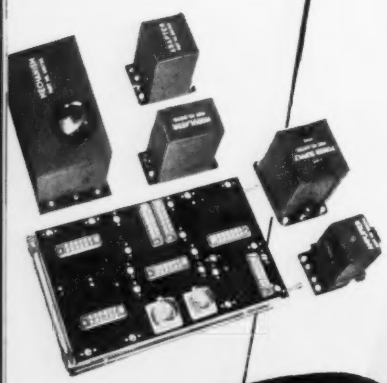

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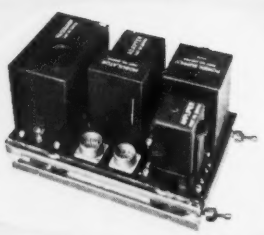

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vantageous to keep the maximum thickness well forward, a conclusion not indicated by linear theory. A long, though interesting, analysis of the Busemann biplane may also be found here. Lastly, a supersonic ram-jet-driven fighter is designed, and its performance is calculated. It is important to note that, generally, the lift-drag ratio increases with altitude.

In addition to the subjects mentioned above, Pope includes most of the material to be found in more advanced books. For the most part, however, the presentation is reduced to a lower level. Other noteworthy features are the integrated student problems (with answers), the references at the end of each chapter, and the usual charts and tables. The author also attempts to correlate theoretical and experimental results wherever possible.

In general, the notation is excellent, and the student's first introduction to the Greek alphabet is softened by a full exposition. One unfortunate symbol is employed: dH is defined as the amount of heat added. At first glance, this objection may appear to be picayune. However, since the student has not yet studied thermodynamics by presumption, the inevitable confusion of enthalpy with dQ will take place.

Alan Pope has set out to write a book on supersonics for undergraduates. He has succeeded admirably.

DR. ROBERT F. BRODSKY
Sandia Corporation

Similitude in Engineering

By Glenn Murphy. New York, The Ronald Press Company, 1950. 302 pp., diagrs. $7.00.

The introduction states that this book "is designed to meet a widely recognized need for an organized presentation of the problems of model design and interpretation of model tests." There can be no doubt that the need exists, and after a careful reading, I feel that the book substantially fulfills its role.

In appraising any product, it would be well, of course, to evaluate its performance against the claims of its designer. However, a seller incurs a degree of responsibility to all buyers who put his product to a reasonable use, even though this use may not have been anticipated in the original design. It is with this broad and demanding view that comments are offered.

The book has three major sections devoted to: (1) The Theory of Similitude and Its Application to Models, (2) Distorted Models, and (3) Dissimilar Models.

The reader will not have progressed far before realizing that Dr. Murphy is a splendid teacher. His discussions go to bedrock. In the section dealing with basic quantities, he is quick to point out that, while length, mass, and time are most generally useful, they are neither basic nor fundamental. The fact that other systems, while convenient in certain respects, often lead to

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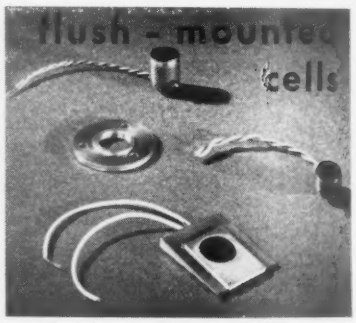

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cumbersome forms is duly noted. Throughout the work such fundamentals are stressed.

A reconsideration of such matters may well profit the aerodynamic fraternity, now snowed under in the multitude of variables fostered by orthogonal projections and L.M.T. units. The revolution introduced into physics by wave mechanics has not reached the grosser phenomena. There are some indications, however, that approaches that may abet the engineer could be developed from polar and perhaps velocity and wave-length units.

Proceeding through the early part, one finds that "in general the interpretation of a set of observations is more difficult than the observations." Certainly Dr. Murphy will have heartfelt agreement. However, his gentle, well-paced instruction should do much to make a justly confident approach to such interpretation grow.

Chapter 2, on Dimensional Analysis, is the canvas on which the author teaches this subject from sketch to finished masterpiece. His skill in selecting for illustration the well-known phenomena of the falling body pays in understandability. He does not speak specifically of the limitations of dimensional analysis. The more valid inspectional analysis procedure is, however, treated implicitly in his discussion, in Chapter 3, of Pi-term selection and in the third part of the work, on dissimilar models. In these implicit treatments, he goes as far as the space and purpose limitations of the book would allow.

Chapter 3 deals with the development of Prediction Equations, and, from this point onward, the book is replete with illustrative problems, Buckingham Pi analyses, formulas describing large numbers of the common engineering phenomena, laboratory exercises, problem assignments, and a table of the physical properties of some fluids. The large bulk of the material enumerated would alone make this a valuable reference book if all discussion were omitted. The extent of space devoted to the illustrative problems and the meticulous attention to detail in their unfolding deserve commendation.

In general, great care has been taken to tabulate symbols at the outset of an operation. In common, however, with most works dealing with mathematics, there is an occasional slip; most can be interpreted from an examination of the context. This mathematical treatment is extremely well done and should present a minimum of difficulty. Indeed, such concise clarity is attained that the book would make good reading for students puzzled by more abstruse treatments in hydrodynamics and the theory of structures.

Part 1 is concluded by the applications of the subject to geometrically similar models.

The first chapter of the second part deals with the development of Prediction Factors for the Distorted Model. The sections adequately outline the treatment of all the elementary struc-

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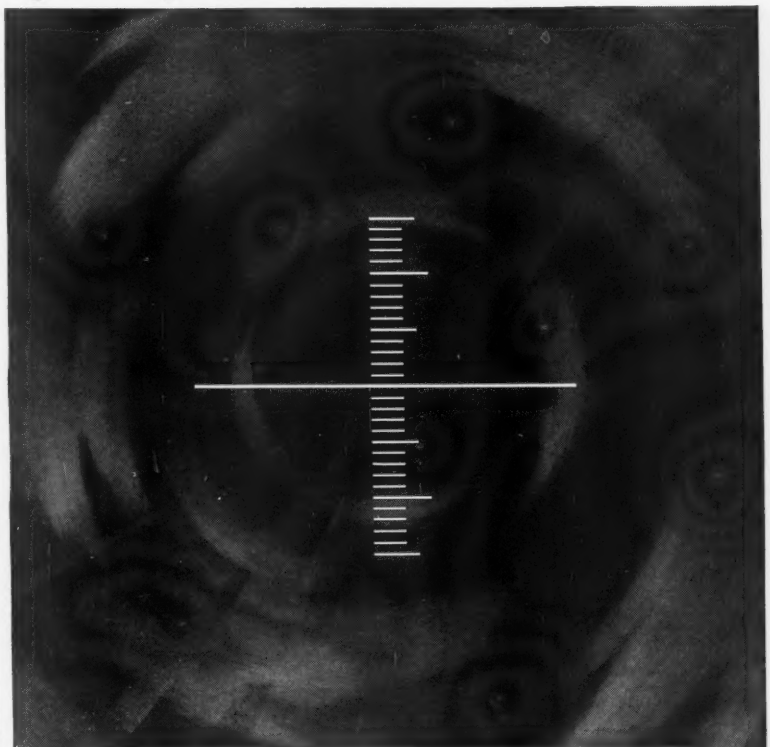

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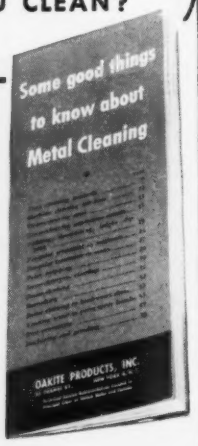

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tural members, open and closed channel fluid flow, aircraft and ship models, waves, thermal models, electric and magnetic models, acoustic and illumination models, and chemical engineering models.

In describing stress and strain, the author has adhered to the classical treatment and limitations. No doubt this practice will displease some, but this section can be easily read and understood by the bulk of the profession. Dr. Murphy has also made liberal use of the teacher's authority to direct and guide the reader or student over the debatable topics in the course of instruction. The practice is good on the whole since it achieves the end of imparting the rules. The exceptions can come later and, for the common run of similitude problems as treated, the student or reader will make no mistake in following his guiding hand. He has, for the conscientious reader, noted the pitfalls, and the chapter-by-chapter bibliography should answer these problems if and when they arise. Many of these references enlarge upon important types of model construction and interpretation. It is unfortunate that the date of publication of the book did not allow the inclusion of that exceptionally valuable report on the use of models, *The Development of High-Speed Water-Based Aircraft*, written by Ernest G. Stout and published in the August, 1950, issue of the JOURNAL OF THE AERONAUTICAL SCIENCES.

The arrangement of Chapter 8, on Fluid Flow, is somewhat questionable. It is a departure from the style of the remainder of the book. It contains a presentation of 27 pages followed by a summary of 8 pages. The summary would appear equally suitable as a foreword, but the material is there and, within the range attempted by the book, complete.

In the models of rivers and harbors, sedimentation is discussed. The problem presented reminds one that some types of air pollution may well be susceptible to model treatment.

The thermal models include the treatment of model gas engines and balloons. The importance of using the absolute thermometric scale is emphasized. In both the thermal and chemical models, the necessity of a series of models for some situations is brought out.

In this second part of the book, a substantial treatment is accorded to the classical numbers of similitude. The Reynolds, Froude, Mach, Weber, Cauchy, Peclet, Prandtl, and Nusselt Numbers are treated both for mathematical form and for physical interpretation.

There are a few faults to find in Chapter 10, where, for example, the important change from thermal to mechanical energy is handled as a sort of afterthought under "scales." Here, too, one of the problems tackles the cooling rate of a steel rod without advance preparation on recalescent points, bubble formation, influence of dissolved gases, nature of the cooling fluid mass and container, etc.

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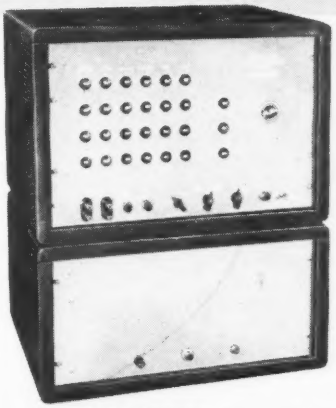

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The third part, on Analogies, is divided according to the mathematical form of the governing equations. Simple two-term algebraic systems, four-term algebraic systems, second- and fourth-order differential equations, and LaPlace and potential forms are included. Among the specific analogies dealt with are: the electrical-stress, stress-fluid flow, network, vibration, vibration-electrical circuit, direct comparison, amplification-unit, pendulum-column, area-moment, conjugate-frame, flow-net, flow-stress, membrane, sand-heap, heat-conduction, diffusion, vacuum-tube, and the electrical potential-torsion analogies. In the last two chapters, the Airy stress function and the slab analogy and the column analogy of Hardy Cross are described.

Previous mention has been made of the fine mathematical treatment. This finds its culmination in Chapter 16, where a simple yet sound treatment of the LaPlace and Poisson equations is followed by the analogies listed above. Throughout this entire section the author's ability to use the simple and the familiar triumphs over what could be a difficult matter.

I think that this book will have wide circulation. It certainly deserves it. However, in one small way the book could be improved. In a classroom text, the exclusion of problem solutions may be debatable. In a book that may be widely used for self-study and reference, such solutions should be available.

The excellent balance of the book is no doubt a product of its refinement in the teaching of this course at Iowa State College. The author's lucid and pleasing language mark an ideal that few technical writers achieve.

For those in the aeronautical sciences, the book deserves a hearty recommendation. It has interest and inspiration and is good background reading and a good reference book. I shall not be surprised if *Similitude in Engineering* becomes a classic.

JAMES L. G. FITZPATRICK
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Planning in Practice

By Ely Devons. London and New York, Cambridge University Press, 1951. 231 pp., diagrs. $3.00.

This is an able analysis and critique of the complex planning functions of Britain's Ministry of Aircraft Production during World War II.

The author, Professor Devons, would seem, by his four years' experience in the planning division of M.A.P., to be well qualified to undertake writing such a book, and it appears to this reader that he has approached his task with both intelligent objectivity and considerable, apparently warranted, candor.

Despite the author's background as an economist, this book is not a conventional "textbook" on the subject of planning, nor does it indulge appreciably

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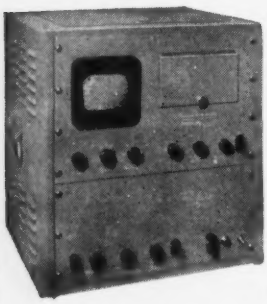

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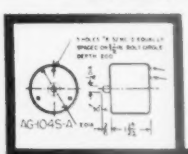

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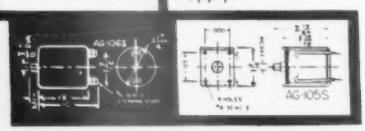

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in classical economic theory. Rather, it is essentially a series of articles or essays examining and analyzing from different angles and in minute detail the functions, faults, failures, and successes of M.A.P. during Britain's critical days. The author weighs the psychological aspects of the British aircraft planning program but properly refrains from drawing specific personalities into the picture.

The reader cannot help being impressed by the extent to which the personal element can affect a complex organization of this sort, and one feels that the author's criticisms of some of the adverse situations, which arose directly or indirectly from this factor, probably are amply justified. Bureaucratic methods and techniques rarely lend themselves to rationalization on either side of the Atlantic.

The Ministry of Aircraft Production, or M.A.P., was the central aeronautical procurement agency and coordinator of aircraft production for the British Government during the last war. As such, it had no exact counterpart in our own Government at that time. In many of its functions, it covered much the same field as does the Air Materiel Command of our own U.S. Air Force, for instance. It was, however, an agency distinctly separate from the British Armed Services and apparently on equal Cabinet footing with the War Office, the Air Ministry, and the Admiralty. M.A.P. had responsibility for planning aircraft production, letting production contracts for aircraft (and in some cases for components on "embodiment loan," similar to our "Government-furnished equipment"), coordinating the efforts of both prime contractors and their subcontractors, arranging for and financing expanded plant facilities, undertaking a certain amount of technical research and development work, and, in short, virtually controlling the entire British aircraft manufacturing industry during this critical period.

The chief problem involved in planning all this activity was the continuous operation of reconciling the demand of the Services for operational aircraft, spare components, and equipment on one hand with the supply possibilities of the nation's aircraft manufacturers on the other. However, as the book forcibly reveals, this apparently simple relationship between supply and demand was vastly complicated in practice by innumerable variables and obstacles, many of them "man-made," which reduced the matter from an analytic process to something less than an art.

After a short description of M.A.P.'s organization and functions, the author plunges into an involved discussion of the "Aircraft Programme," or planned aircraft production schedule, which, as the author points out, was necessarily constantly changing. This fluid program became the key factor in all M.A.P. planning and coordination, and the author has treated its various as-

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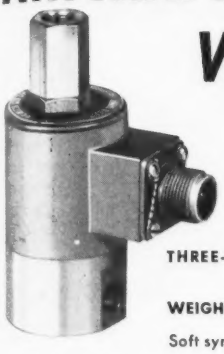

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pects in great detail. Particularly interesting are his views and analyses of "target" versus "realistic" programs, in which he discusses the shortcomings and advantages of each with particular reference to the evil effects of badly distorted "target" programs.

The supplies of components, equipment, and aircraft engines also presented some knotty problems to M.A.P. planners, since operational spares in these categories were ordered directly by the Air Ministry and the Admiralty, sometimes to the detriment of M.A.P.'s main aircraft production plans. Coordination and reconciliation of spares procurement with procurement of new aircraft were necessary functions of M.A.P. and apparently resulted in considerable maneuvering between that agency and the Armed Services at times.

The author also goes deeply into the matters of productive capacity of the industrial units involved, the labor requirements of the industry, the statistical aspects of planning, and the coordinating functions of M.A.P.'s Directorate-General of Planning, Programs, and Statistics.

The labor requirements of the British aircraft industry during this period were furnished to M.A.P. by allotment of certain elements of the British labor force by the Ministry of Labor. In the early days of the war, while British industrial capacity was expanding to a wartime footing, labor apparently was not in critically short supply. At length, however, the British war economy became saturated, considerable competition resulted between segments of the economy at Ministry level for available labor allotments, and the labor supply became a key factor in determining the size of the aircraft program. In fact, as the author reveals, about 1944, labor began to be diverted from the aircraft industry to other work, including the civilian economy, with an inevitable cutback in the aircraft program.

Statistics played a powerful role in many top policy decisions. However, the author indicates that the knowledge and understanding of statistical analysis on the part of some of the responsible M.A.P. officials was considerably less than perfect. He gives several amusing examples to illustrate his point.

Unlike the main portion of the book, which deals in rather involved generalities and analytic considerations, the last part, or Appendix, is devoted to the hard facts of the aircraft components supply in June, 1944, as an example of that particular problem. Particular reference is made here to procurement of American-made Packard "Merlins," American propeller assemblies, and Martin turrets.

It is rather difficult for an American to state a definite opinion with regard to the subject matter of this book. Certainly the meanderings of some of our own Government bureaus are not invulnerable to criticism, but the reader of this book cannot escape the impression that there was plenty of room for improvement in some of the operating practices of Britain's wartime M.A.P. In fact, much of this work is devoted to a commentary on the failure of formal, accurate planning to meet the requirements of the situation. As a joint procurement agency, however, M.A.P. proved workable. Some study of its practices might be interesting to those responsible for aeronautical procurement in this country.

Generally speaking, it is felt that Professor Devons has made a good presentation of a difficult subject. However, because his explanations sometimes become involved, a few more figures, diagrams, organizational charts, etc., might have improved the work's readability.

From the academic standpoint, at least, this book should interest businessmen, economists, and engineers associated with the American aviation industry. It would be interesting to see someone in the U.S. try to analyze American aviation procurement and planning in a similar manner for comparative purposes. Much informative material might thus be brought to light for the purpose of improving our own methods and policies during the current defense emergency.

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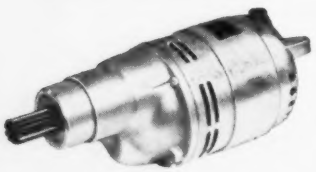

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Jet Aircraft Power Systems; Principles and Maintenance

By Jack V. Casamassa. New York, McGraw-Hill Book Company, Inc., 1950. 338 pp., diagrs. $5.50.

The formation and development of a textbook to prepare aircraft mechanics for maintenance and overhaul of jet aircraft propulsion units and their associated accessories are not easy tasks. The editor is among the first to attempt this objective for presentation to civilian-trained aircraft mechanics.

The prime questions of objectives and choice of method of instruction are necessarily determining factors in the development of any textbook. The apparent objective of this text is to present a wide coverage of present-day factual knowledge regarding all operational phases of jet aircraft power systems. The method of instruction is in the main descriptive and leans heavily on the theory that an accumulation of factual knowledge coupled with a mechanical sense of the principles of thermal and fluid phenomena will provide the background knowledge required for an understanding of the maintenance and operational problems of present and future high-speed aircraft.

The book is not intended for design engineers or for a presentation of the theoretical principles usually required at a college level. Accordingly, there is no need for a mathematical presentation of the theoretical principles involved such as is available in a number of excellent textbooks for college courses on the theory of jet engines. Rather, the editor has presented one of the first books on jet and turboprop engines definitely slanted for the practical use of aircraft mechanics and all those who wish both general and detailed operational information. Thus, it launches into a channel of knowledge unbroken until now. In the wake of such a rapidly advancing technology, it is true that there will be many shifts and changes in the stream bed just as there are still so many depths of research unexplored, but, during the process, this book will be of great help since it presents a compilation of the existing factual knowledge that can be released on the art of jet engines as it exists today.

The material treated is divided into four sections. Part I, The History and Design of Jet Machines, relates a brief study of ancient and modern developments of the jet idea and then describes the major differences between turbojets, turboprops, athodyds, and rockets. It concludes with a summary of the general advantages and disadvantages of existing models of these different types.

Part II begins with a comparatively brief nontechnical explanation of jet-propulsion theory and then considers installation practices and problems. The integration of a jet engine with its aircraft entails such problems as air inlets and cooling and exhaust systems along with thrust-augmentation methods that may be related directly to the design of the air frame or to an integral part of the jet engine.

Part III is entitled Systems. This section includes, along with a discussion of a number of specific fuel, lubrication, starter, and electrical systems, a survey of available materials and fuels.

Part IV, Servicing and Operation, treats a variety of topics including production problems; service experience; inspection, maintenance and overhaul; compound engines; and jet transports.

An addendum incorporates a further compilation of some of the data released during the short time that had elapsed between the first collection that constitutes the main part of the book and the printing of the book.

ROBERT A. KILLOREN
Department of
Aeronautical Engineering
Parks College of
Aeronautical Technology
St. Louis University

Book Notes

AERODYNAMICS

Handbook of Supersonic Aerodynamics: Section 5, Compressible Flow Tables and Graphs. Compiled and Edited Under Bureau of Ordnance Contract NOrd 7386 by The Aerodynamics Handbook Staff of The Johns Hopkins University Applied Physics Laboratory. (NAVORD Report No. 1488, Vol. 2.) Washington, U.S. Govt. Printing Office, 1950. 194 pp., diagrs. $1.50.

The first volume, published early in 1950 ($1.75) covered symbols and nomenclature, fundamental equations and formulas, general atmospheric data, and The Mechanics and Thermodynamics of Steady One-Dimensional Gas Flow. The present volume contains tables and graphs on Isentropic Flow Functions; Normal Shock Flow Functions; Oblique-Shock Flow Functions; Prandtl-Meyer Flow Functions; First, Second, and Third Busemann Coefficients and Altitude Functions, including Reynolds Number As a Function of Altitude, and Dynamic Pressure As a Function of Altitude.

AERONAUTICS

Airline Transport Pilot Rating. Charles A. Zweng and Allan C. Zweng. North Hollywood, Calif., Pan American Navigation Service. 1950. 423 pp., illus., $4.00.

In this latest edition of a standard work last revised in 1947, new material covers principally the changes in Civil Air Regulations, new developments in navigation and meteorology, and new questions for pilot applicants in the multiple-choice type of examinations. Instrument flying by both the 1-2-3 system and the "attitude" method, using the gyro horizon; the radio range, including the VHF radio range, radio aids to navigation, and instrument landing systems; radio-compass navigation, chart reading, and dead reckoning; and weather maps, sequence reports, air masses and fronts, thunderstorms, winds, fog, ice, weather forecasting, and flight planning are the principal subjects discussed. There are separate chapters on the Civil Air Regulations and on air-traffic rules and traffic control. Examination questions are included.

Statistical Study of U.S. Civil Aircraft As of July 1, 1950. Washington, U.S. Civil Aeronautics Administration, 1950. 38 pp.

AIRPORTS

Airport Terminal Activities and Space Utilization. U.S. Civil Aeronautics Administration. Washington, U.S. Govt. Printing Office, July, 1950. 64 pp., diagrs. $0.35.

Effective Community Air Traffic Potential (Airport Planning). Washington, U.S. Civil Aeronautics Administration, June, 1950. 35 pp., diagrs.

Seaplane Facilities. U.S. Civil Aeronautics Administration. Washington, U.S. Govt. Printing Office, May, 1950. 54 pp. $0.25.

ELECTRONICS

Theory and Application of Industrial Electronics. John M. Cage, With the Assistance of C. J. Bashe. New York, McGraw-Hill Book Company, Inc., 1951. 290 pp., illus., diagrs. $4.75.

This book is designed to develop an integrated set of concepts, basic circuits, devices, and techniques outside the field of communications for the college engineering student who has studied one or more courses in basic electronics or radio engineering. Electronic instrumentation of both electrical and nonelectrical quantities; electronic control, including servomechanisms; and electronic power, including d-c power, induction heating, and dielectric heating are some specific subjects covered. References are given at the ends of chapters. The author is a Professor of Electrical Engineering at Purdue University. Mr. Bashe is a Research Engineer with the International Business Machines Corporation.

Principles of Microwave Circuits. Edited by C. G. Montgomery, R. H. Dicke, and E. M. Purcell. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 8.) New York, McGraw-Hill Book Company, Inc., 1948. 486 pp., diagrs. $6.50.

This volume deals with the impedance concept and the equivalent circuits of microwave devices, with emphasis on underlying principles and the results that may be obtained by their use. Specific devices are discussed only as illustrations of the general methods under consideration. Following introductory chapters on Electromagnetic Waves, Waveguides As Transmission Lines, and Elements of Network Theory, the discussion takes up General Microwave Circuit Theorems, Waveguide Circuit Elements, Resonant Cavities, Waveguide Junctions with Several Arms, and Mode Transformations. The book ends with chapters on Dielectrics in Waveguides and the Symmetry of Waveguide Junctions. The editors are faculty members in the physics departments of Yale, Princeton, and Harvard Universities, respectively.

Propagation of Short Radio Waves. Edited by Donald E. Kerr. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 13.) New York, McGraw-Hill Book Company, Inc., 1951. Illus., diagrs. $10.

This volume deals with the phenomena associated with the propagation of short radio waves between terminal points, presenting a summary of the state of knowledge in this field at the end of the war. The eight chapters are: Elements of the Problem, John E. Freehafer and Donald E. Kerr. Theory of Propagation in a Horizontally Stratified Atmosphere, John E. Freehafer, William T. Fishback, Wendell T. Furry, and Donald E. Kerr. Meteorology of the Refraction Problem, Richard A. Craig, Isadore Katz, R. B. Montgomery, and Pearl J. Rubenstein. Experimental Studies of Refraction, Pearl J. Rubenstein, Donald E. Kerr, and William T. Fishback. Reflections from the Earth's Surface, Donald E. Kerr, William T. Fishback, and Herbert Goldstein. Radar Targets and Echoes, Donald E. Kerr and Herbert Goldstein. Meteorological Echoes, Herbert Goldstein, Donald E. Kerr, and Arthur E. Bent. Atmospheric Attenuation, J. H. Van Vleck, E. M. Purcell, and Herbert Goldstein.

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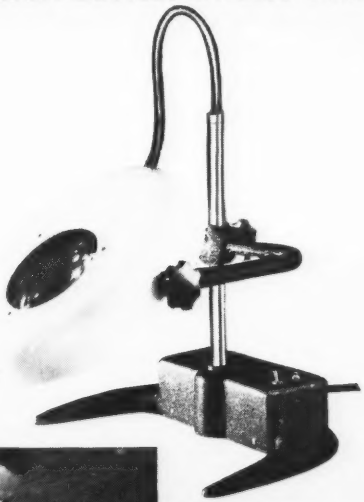

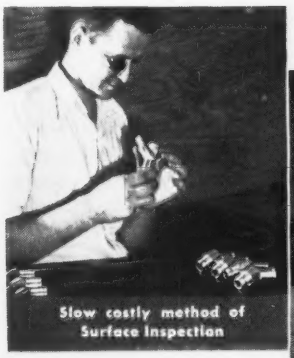
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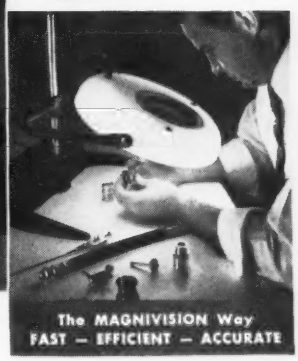
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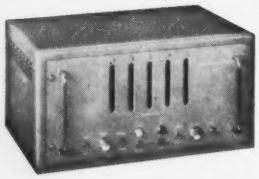

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THE BERKELEY EVENTS-PER-UNIT TIME* Meter will automatically count and display the number of events that occur during a precise one second interval at rates up to 100,000 per second. Accuracy is ± one event. These events may be any mechanical, electrical, or optical occurrences regularly or randomly spaced that can be converted into changing voltages. Thus the EPUT becomes an extremely flexible tool which may be used as a precision electronic tachometer, a secondary frequency standard, a device for rapid determination of unknown frequencies or simply a multi-purpose general laboratory instrument.

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MODIFICATIONS: Standard modifications available: a selectable 0.1, 1, and 10 second time base; addition of mechanical register for extended range; addition of panel switch to permit use as straight counter; scanning feature to provide a time base in any multiple of 10 seconds. Special modification including accessories such as tachometer pickups and photocell arrangements can be supplied to meet specific requirements.

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- PRECISE LOW-FREQUENCY MEASUREMENTS
- HIGH SPEED COUNTING

THE BERKELEY TIME INTERVAL METER*, Model 510, provides a direct reading of elapsed time between any two events in the range of 0.000010 to 1.0000 seconds. Accuracy of measurement is ± 10 u/secs. Any occurrences that can be translated into changing voltages may be timed. Timing may be started and stopped by independent voltages. The polarity of these control voltages may be selected by means of toggle switches so that the unit may be started and stopped by either positive or negative pulses. A sensitivity control permits selection of the amplitude of the start or stop voltages at optimum level for elimination of interference.

OPERATION: By use of photocell attachments the interval between two separate light flashes may be timed. Similarly by use of an added photochannel and a single photocell duration of a light period or a dark period may be determined.

MODIFICATIONS: Standard modifications available: addition of a photocell channel; the addition of a mechanical register to extend range to 10 seconds; threshhold control to permit selection of precise amplitude of input pulse so unit may be made to operate at any desired position on sine wave; panel switch to permit use as straight counter.

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Indexes of names and subjects are included, together with an appendix on the Application of the Lorentz Reciprocity Theorem to Scattering and on Coherent and Incoherent Scattering from Assemblies of Scatterers.

ENGINEERING

Engineers' Council for Professional Development: Annual Report for Year Ending September 30, 1950. New York, 1951. 53 pp. $0.50.

Reports are presented of the Committees on Student Selection and Guidance, Engineering Schools, Professional Training, Professional Recognition, Information, Engineering Ethics, and Unity and of the representatives of constituent organizations. The best known committee of E.C.P.D. is that on Engineering Schools which, since 1935, has examined and accredited 656 engineering curricula in 142 engineering schools. The list of accredited curricula, printed in this report, now includes 29 aeronautical engineering curricula and 21 curricula in which aeronautical engineering specialization is an option as part of the mechanical engineering course. Five technical institutes are also accredited.

EQUIPMENT, ELECTRICAL

Electrician's Mate 3. Prepared by U.S. Bureau of Naval Personnel. (Navy Training Courses, NavPers 10548.) Washington, U.S. Govt. Printing Office, 1950. 357 pp., illus., diagrs. $1.00.

FUELS & LUBRICANTS

The Practice of Lubrication. T. C. Thomsen. 4th Ed. New York, McGraw-Hill Book Company, Inc., 1951. 617 pp., diagrs. $8.00.

This book was last revised in 1937. In the present edition, a new chapter on Engine-Oil Additives is included. New developments in production, refining, blending, synthetic oils, and new solvent refining processes are presented. The lubrication of aircraft engines and accessories is discussed on pages 512–516. The original purpose, to provide "an engineering treatise on the origin, nature and testing of lubricants, their selection, application and use," is retained. The author, now an independent consulting engineer in Denmark, was for many years Chief Engineer of the Vacuum Oil Company, Ltd., in London.

World Geography of Petroleum. Edited by Wallace E. Pratt and Dorothy Good. (American Geographical Society, Special Publication No. 31.) Princeton, N.J., Princeton University Press, 1950. 464 pp., illus., maps. $7.50.

The greater part of this comprehensive and authoritative book (286 pages) is devoted to the world's productive regions, including both the Eastern and Western Hemispheres. Three chapters cover potential productive areas, especially the polar regions and the continental shelves on the sea floor. The finding of oil-bearing areas and the organization and methods of the industry are covered in two opening sections. The final section, on Aspects of Utilization, covers the availability of petroleum today and tomorrow, its use in World War II, civilian utilization, a statistical survey, and the effect of world distribution of petroleum on the power and policy of nations. A 22-page bibliography and 60 maps are included.

INSTRUMENTS

Instrumentation Flow Plan Symbols. (Tentative Recommended Practice No. RP 5.1.) Pittsburgh 12, Pa., Instrument Society of America, 1949. 14 pp. $1.00.

Radiation Instrument Catalog. (U.S. Atomic Energy Commission, Division of Biology and Medicine, Radiation Instruments Branch.) Washington, U.S. Office of Technical Services, 1950. 2 Vols. Illus. $2.00 per set.

MACHINE ELEMENTS

Introduction to Mechanical Design. T. B. Jefferson and Walter J. Brooking. New York,

Ronald Press Company, 1951. 612 pp., illus. diagrs. $6.50.

This textbook aims to present machine design as seen by the experienced designer, considering the function of the machine, its configuration requirements, economic considerations, the use of rational and empirical design data, and desired final appearance, as these are weighed by the designer. The elementary theory of machine elements is presented against this background, with particular emphasis on materials, manufacturing processes, machine frames, lubrication, styling, streamlining, and finishing. Pipes, tubing, tanks and containers, and the use of standardized available machine elements are also considered. Separate chapters are also included on Bolted and Riveted Connections; Screws; Welded Fastenings and Joints; Shafting, Keys, and Couplings; Friction Gearing, Brakes, and Clutches; Gears and Flywheels; Belt, Rope, and Chain Drives; Cams, Linkages, and Miscellaneous Devices; and Springs. Bibliographies are included at the ends of chapters. This book was awarded first prize in the Machine Design Division of the competitive program for modernized textbooks on design, sponsored by the James F. Lincoln Arc Welding Foundation. Mr. Jefferson is editor of *The Welding Engineer*, and Mr. Brooking is associated with the Special Projects Department, M. W. Kellogg Company.

MANAGEMENT & FINANCE

Executive Action. Edmund P. Learned, David N. Ulrich, and Donald R. Booz. Boston 63, Division of Research, Graduate School of Business Administration, Harvard University, 1951. 218 pp. $3.25.

Data for this book were gathered largely by direct interview with high-level executives in industry, supplemented by files of case studies at the Harvard Business School and by an intensive study of working relations among executives of a small sample of twelve companies located in various parts of the country. The book is designed to state and deal with the problem of coordination at the top level and among the various parts of an industrial enterprise. The discussion is in terms of human relations. In the first part (81 pages) the human factors in the background of executive action are discussed. The second part (131 pages) is concerned with major aspects of executive action. Administration is concluded to be a team job, particularly in the larger organization, and a continuing job having no complete solution. Subordinates frequently were found to be underrated on their capacity to assume greater responsibility. Frequent personal contact is essential to effective administration all along the line. Executive teams should be small enough to allow this. The best results depend on the improved capacity of executives and supervisors to coordinate human efforts, rather than the addition of more echelons of supervision.

A Study of the Fairchild Engine and Airplane Corporation; With a Brief Review of the Current Strategic Position of the Aircraft Industry. New York, Selig Altschul Aviation Advisory Service, 1950. 73 pp.

MATERIALS

The Behavior of Engineering Metals. H. W. Gillett. New York, John Wiley & Sons, Inc., 1951. 395 pp., diagrs. $6.50.

This book is intended for designers, production engineers, purchasing agents, sales engineers, and others not specializing in metallurgy. Engineering facts on the behavior of metals are emphasized. Following six introductory chapters on the basic concepts of metallurgy, the next nine chapters deal with the behavior of the principal industrial metals and alloys. The final nine chapters cover such considerations as machinability, clad and coated metals, metal films and surfaces, powders, bearing metals, and severe service of surfaces and of metals at very high and very low temperatures. The final chapter covers costs and availability. Sources of more detailed information are discussed in an ap-

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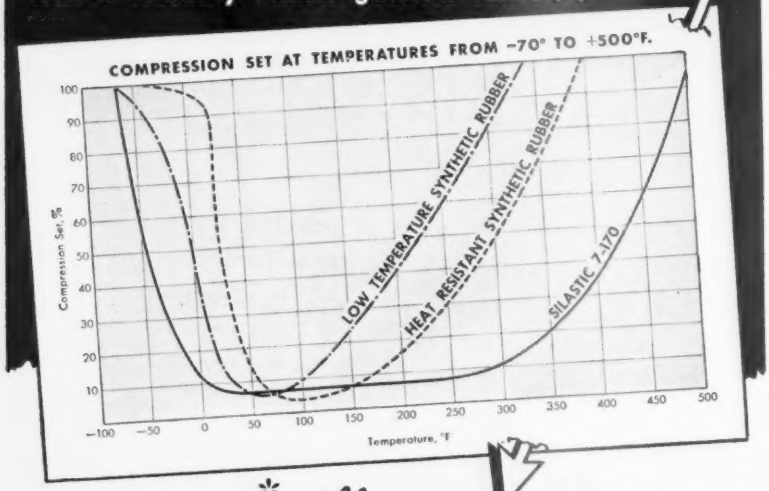

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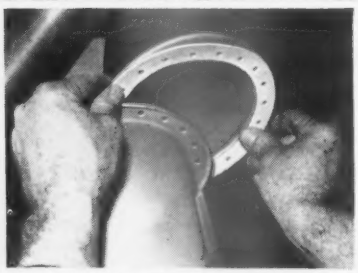

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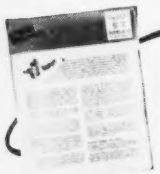

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pendix, and bibliographies are included at the ends of chapters. Dr. Gillett was for more than 20 years Chief Technical Advisor of the Battelle Memorial Institute.

Symposium on Plasticity and Creep of Metals. (Special Technical Publication No. 107.) Philadelphia, American Society for Testing Materials, 1950. 68 pp., illus., diagrs. $1.50.

Contents: The Experimental Exploration of Plastic Flow in Sheet Metals, L. R. Jackson and W. T. Lankford. Forming Parameters and Criteria for Design and Production, William Schroeder. The Use of Creep Data in Design, Howard C. Cross and L. R. Jackson. Super Creep-Resistant Alloys, J. W. Freeman, D. N. Frey, E. E. Reynolds, and A. E. White.

The Physics of Powder Metallurgy. Edited by Walter E. Kingston. New York, McGraw-Hill Book Company, Inc., 1951. 404 pp., illus., diagrs. $8.50.

This symposium was held at Bayside, L.I., August 24–26, 1949, under the sponsorship of the Metallurgical Laboratories of Sylvania Electric Products, Inc.

Contents: Fundamental Problems of Sintering Processes, W. E. Kingston and G. F. Huettig. Mechanism of Crystal Growth, A. G. Smekal. Orientation in Recrystallization and Grain Growth, P. A. Back. Recrystallization, Marian Balicki. Structure and Behavior of Grain Boundaries, M. R. Achter and Roman Smoluchowski. Self-Diffusion in Iron, F. S. Buffington, I. D. Bakalar, and Morris Cohen. Homogeneous Nucleation, David Turnbull and J. H. Hollomon. Surface Tension As a Motivation for Sintering, Conyers Herring. Relationships Between Properties and Structure of Sintered Material Made Up of a Single Atom Type, G. F. Huettig, K. Adlassnig, and O. Foglar. Shrinkage of Synthetic Pores in Copper, A. W. Postlethwaite and A. J. Shaler. Relations Between Diffusion and Viscous Flow in Metals, B. H. Alexander, G. C. Kuczynski, and M. H. Dawson. Examination of Subgrain Structures with the Electron Microscope, Laurence Delisle and G. A. Davis. Sintering of Copper-Gold Alloys, Pol Duwez and C. B. Jordan. Sintering with a Liquid Phase, F. V. Lenel. The Principles and Present Status of Hot Pressing, C. G. Goetzel. Theoretical Aspects of Sintering of Carbides, Richard Kieffer. Experimental Production of Pure Titanium Carbide Powder by Means of Carburizing Gases, Volker Fattinger. Nature of Metal Powders Prepared by Reduction of Oxides, Bernard Kopelman. Particle-Size Distribution of Tungsten and Molybdenum Powders, A. D. Power and I. M. Kakacsik. Electrical Properties As Indicators of the Degree of Sintering, H. H. Hausner and J. H. Dedrick. Fundamentals of Pressing of Metal Powders, R. P. Seelig. Alloy Powder Products from Fully Alloyed Powders, G. J. Comstock and J. D. Shaw.

Metal Cleaning Bibliographical Abstracts, 1950 Supplement. Jay C. Harris. (Special Technical Publication No. 90-A.) Philadelphia, American Society for Testing Materials, 1950. 27 pp. $1.00.

About 89 abstracts are added for the period 1932–1948 and 80 abstracts for 1949–1950 bringing the total, with the original bibliography published in 1949, to more than 660. Indexes by subjects, authors, specifications, and patent numbers are included.

Joint Committee on Rheology of the International Council of Scientific Unions, Report on the Principles of Rheological Nomenclature. J. M. Burgers and G. W. Scott Blair. Amsterdam, North-Holland Publishing Company, 1949. 72 pp. $2.50.

Finishes for Aluminum. Revised Ed. Louisville, Ky., Reynolds Metals Company, 1950. 124 pp., illus.

Indium; Discovery, Occurrence, Development, Physical and Chemical Characteristics, and Bibliography of Indium (Annotated), 1863–1949 Inclusive. Compiled by Maria Thompson Ludwick. New York, Indium Corporation of America, 1950. 276 pp.

Plastics Research and Technology at the National Bureau of Standards; A Review and

Bibliography. Gordon M. Kline. (N.B.S. Circular No. 494.) Washington, U.S. Govt. Printing Office, June 15, 1950. 14 pp. $0.15.

Aluminium Alloy Castings. (A.D.A. Information Bulletin No. 17.) London, The Aluminium Development Association, May, 1950. 45 pp., illus., diagrs. 1s.

METEOROLOGY

Climate and Weather for Flight in Naval Operational Zones. Prepared by U.S. Naval Air Training Command, Pensacola, Fla. Washington, U.S. Govt. Printing Office, 1951 (1944). 203 pp., illus., maps. $0.55.

Russian-English Dictionary of Meteorological Terms and Expressions. Werner A. Baum. Washington, Hobart Publishing Company, 1949. 126 pp. $7.50.

MILITARY AVIATION

Air Force Procurement Procedures. (U.S. Air Force Manual No. AFM 70-6.) Washington, U.S. Govt. Printing Office, June, 1950. 65 pp. $1.00.

NAVIGATION

Program, Air Navigation Development Board. Washington, U.S. Air Navigation Development Board, December 1, 1950. 111 pp.

PERSONAL FLYING

Personal Aircraft Inspection Manual. (U.S., Civil Aeronautics Administration, Technical Manual No. 101.) Washington, U.S. Govt. Printing Office, November, 1950. 81 pp., illus. $0.55.

PRODUCTION

Die Casting. H. H. Doehler. New York, McGraw-Hill Book Company, Inc., 1951. 502 pp., illus., diagrs. $8.00.

The first five chapters deal with die-casting machines, the die, the part design, and the practical aspects of the die-casting process. Three metallurgical chapters cover the alloys, die steels, and finishing. The final chapters cover machining, trimming, inspection, cost estimation, and safety. The author aims to discuss present production methods and design techniques in die casting, and to point out the possibilities and trends for the future of this process, which are considered unlimited. The author is Chairman of the Board of the Doehler-Jarvis Corporation.

Machinability and Machining of Metals. Norman E. Woldman and Robert C. Gibbons. New York, McGraw-Hill Book Company, Inc., 1951. 518 pp., illus., diagrs. $7.50.

The two general purposes of the authors are to cover the metallurgy and machining characteristics of metals and their alloys, and the actual cutting of the metals—that is, the machining operations. More specific aims are to suggest tool design, cutting speeds, feeds, and type of cutting fluid for satisfactory results; to point out where common practice and standard design tools may be used, and to suggest where special practices or tools are needed. For each metal, the discussion proceeds from its metallurgy to the tools used and the operations involved in its machining. References are given at the ends of chapters. The book is an excellent survey of current practice. Dr. Woldman is a consulting metallurgical engineer, and Mr. Gibbons is a Metallurgical Engineer with the Eclipse-Pioneer Division, Bendix Aviation Corporation.

How to Chart Timestudy Data. Phil Carroll. New York, McGraw-Hill Book Company, Inc., 1950. 323 pp., diagrs. $5.00.

Charting procedures are presented for the standard data method, improvement of time-study methods, forms of standard data, standards for curve drawing, time-study data curves, curves as planning controls, and equations in time study. Alignment charts and their applications, multiple curves, multivariable charts, and constant per cent charts are others discussed. The author points out that the charting methods

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discussed, except for alignment charts, are not in other books on time-study methods. This book is an expansion of Chapters 13, 14, and 15 of his *Timestudy for Cost Control* (2nd Ed., 1943) and requires accuracy in simple arithmetic through decimals as the minimum mathematical qualification of the reader.

Quality Control; Principles, Practice and Administration. A. V. Feigenbaum. New York, McGraw-Hill Book Company, Inc., 1951. 443 pp., diagrs. $7.00.

The discussion in this book is divided into four parts, covering quality control from the overall administrative point of view, from the statistical point of view, its application in the plant, and its introduction into the plant. A final chapter summarizes the subject in the form of detailed answers to nine questions about quality control. A bibliography of 30 references on statistical quality control is included. The author is Secretary of the Quality Control Coordinating Committee, General Electric Company.

Lessons in Lettering. Thomas B. French and William D. Turnbull, Revised by A. J. Philby. 3rd Ed. New York, McGraw-Hill Book Company, Inc., 1950. 2 Vols. 40, 40 pp., illus. $0.60 per Vol.

These two volumes, last revised in 1921, are the first in a series of practice books. Book 1 covers the Vertical Single Stroke, and Book 2 covers the Inclined Single Stroke. The authors are associated with the Department of Engineering Drawing at The Ohio State University.

REFERENCE WORKS

BIBLIOGRAPHIES

Educators Guide to Free Films. Compiled by Mary Foley Horkheimer and John W. Diffor. 10th Ed. Randolph, Wis., 1950. 392 pp. $5.00.

In this new annual edition, over 25 per cent of the 1,927 titles were not previously listed. About 60 of the new titles cover various technical aspects of aeronautics. Others deal with air transportation, airports, air power, atomic bomb tests, aluminum, magnesium, various production processes, machine tools, electronics, physics, and other related sciences. Indexes of titles, subjects, and sources of films are included.

A List of British Scientific Publications Reporting Original Work or Critical Reviews. (The Royal Society, Information Services Committee.) London, Cambridge University Press, 1950. 95 pp. 2*s*. 6*d*.

DICTIONARIES

German-English Technical Dictionary of Aeronautics: Rocketry, Space Navigation, Atomic Physics, Higher Mathematics, Jet Engines, Turbines, Hydraulics, Petroleum Industry, Civil and Mechanical Engineering, Ballistics, Electronics, Radio, Radar, Aerophotography, Television, Infrared Research, Communication, Meteorology, Topography, Aeromedicine. Edited by Kurt F. Leidecker. New York, S. F. Vanni, Publishers and Booksellers; Distributed by Charles A. Meyers and Company, Nyack, N.Y., 1951. 2 Vols. 968 pp. $35 per set.

In this excellent dictionary the English equivalents are given of more than 100,000 German technical words. Two or more English equivalents are given for about 20 per cent of the terms. Theoretical terms are liberally included, and there is a wide coverage of technical and scientific fields related to aeronautics, as indicated roughly by the subjects mentioned on the title page. Special features are the inclusion of abbreviations occurring in the technical literature for the names of companies, for words, and for German military and other groups and units. Letter symbols and code symbols are also included. The greater part of the vocabulary of this dictionary was derived from thousands of captured German reports covering the latest Axis research and theory on aircraft, propulsion, weapons, production methods, military organization and tactics, and the underlying sciences. The basic work was done by the editor and his assistants under the direction of the U.S. Air Force beginning in 1945, first in Europe, then in London, and finally at Dayton, Ohio, where the German documents program was completed.

Aviation Dictionary; English-Spanish, Spanish-English. (U.S. Air Force Manual No. AFM 900-1.) Washington, U.S. Govt. Printing Office, 1950. 325 pp. $0.70.

Dicionário Aerotécnico Inglês-Português. Carlos Nayfield. Rio de Janeiro, Cía. Editôra Leitura, 1945. 331 pp. $6.00.

Flyglexikon; Svenskt-Engelskt, Engelskt-Svenkst. L. Sundström. Stockholm, A.-B. Linqvists Förlag, 1946. 216 pp. $4.75.

Aviation; A Technical Dictionary, English-French and Français-Anglais. Paris, Henri Didier, 1945. 2 Vols. in one. 239, 209 pp. $1.00.

RESEARCH

Fiscal and Budgetary Phases of Research; A Selected List of References. Compiled by Helen Dudenbostel Jones. Washington, Library of Congress, General Reference and Bibliography Division, 1949. 33 pp.

SCIENCES, GENERAL

GEOGRAPHY

Geography of the Pacific. Edited by Otis W. Freeman. New York, John Wiley & Sons, Inc., 1951. 573 pp., illus., maps. $10.

This volume, written by 13 authorities, is intended to fill the need for a single comprehensive source on the climates, currents, trade routes, strategic and political significance, and the general human, economic, and political geography of the Pacific area. The greater part of the book is concerned with 15 areas, all consisting of island groups except for Australia. Other continents are considered only as terminal points for trade routes. A great deal of scattered information is gathered into this authoritative volume.

MATHEMATICS

Technological Applications of Statistics. L. H. C. Tippett. New York, John Wiley & Sons, Inc., 1950. 189 pp., diagrs. $3.50.

Based on a set of lectures delivered in 1948 at the Massachusetts Institute of Technology, this book is described by the author as an introduction and companion to a systematic textbook on applied statistics. The emphasis is upon basic assumptions and their implications for the technologist and points arising in practical applications of the methods. The exposition is developed from examples, using arithmetic procedures rather than mathematical proofs. The first part deals with The Routine Control of Quality, covering quality measurement, theory and practical application of control-chart procedure, control of the fraction defective, and acceptance sampling. The second part covers Investigation and Experimentation, including the theory and application of the statistical theory of errors, analysis of variance, and correlation analysis. A brief bibliography is included. The author is Head of the Mechanical Processing Division of the British Cotton Industry Research Association.

Tables for Conversion of X-Ray Diffraction Angles to Interplanar Spacing. (U.S., National Bureau of Standards, Computation Laboratory, Applied Mathematics Series, No. 10.) Washington, U.S. Govt. Printing Office, 1950. 159 pp. $1.75.

In the first six tables, spacing values are given in angstrom units, using wave lengths established in London in 1946 for X-ray targets of molybdenum, copper, nickel, cobalt, iron, and chromium for θ angles from 0° to 90° at intervals of 0.01°. In the last two tables, the data for copper and iron are rearranged for the argument 2θ from 0° to 180° at intervals of 0.02°. The work was sponsored by the Office of Air Research, Air Materiel Command, U.S. Air Force.

Differential and Integral Calculus. Edmund Landau. Translated from the German by Melvin Haussner and Martin Davis. New York, Chelsea Publishing Company, 1951. 366 pp. $4.50.

This is a translation of Professor Landau's *Einführung in die Differentialrechnung und Integralrechnung* (Gröningen-Batavia, 1934). The author's aim is to present a formal, rigorous, and reasonably complete treatment selected from his most recent courses. Applications of the calculus are not emphasized, and the author recommends that this book be supplemented by a collection of problems for those who wish to practice on a number of examples. Geometric applications are likewise omitted. Infinite series are included.

A Manual for the Slide Rule. Paul E. Machovina. New York, McGraw-Hill Book Company, Inc., 1950. 78 pp., illus. $0.75.

Designed for use in a short course on the slide rule, this text covers its construction, manipulation, and theory, proceeding into simple calculations. The last half of the book is concerned with the folded and inverted scales, combined operations, squares and cubes and their roots, logarithms and the *L* scale, trigonometric scales, and the log-log scales. Problems are given on the last twelve pages. The author is an Associate Professor in the Department of Engineering Drawing at The Ohio State University.

Practical Mathematics. Part II—Algebra with Applications. Claude Irwin Palmer and Samuel Fletcher Bibb. 5th Ed. New York, McGraw-Hill Book Company, Inc., 1950. 252 pp., diagrs. $2.40.

In this new edition of a standard text last revised in 1941, a new chapter on progressions has been added, and a number of additions have been made to the text and to the problems. Dr. Palmer was a Professor of Mathematics and Dean of Students, and Dr. Bibb is Associate Professor of Mathematics at the Armour College of Engineering.

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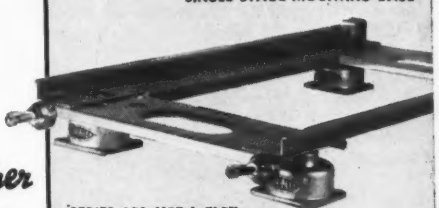
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PHYSICS

Applied Nuclear Physics. Ernest C. Pollard and William L. Davidson. 2nd Ed. New York, John Wiley & Sons, Inc., 1951. 352 pp., illus., diagrs. $5.00.

This book was first published in 1942. This edition retains the authors' purpose to present the essential factors of nuclear physics, emphasizing the technical aspect of the subject. A new chapter on nuclear chain reactions and special sections on pile theory, neutron diffraction, cross sections, cosmic rays, and laboratory experiments have been added. References are given at the ends of chapters. Professor Pollard teaches physics at Yale University, and Dr. Davidson is Director of Physical Research, The B. F. Goodrich Company.

Bibliography of Electron Microscopy. Claire Morton, Samuel Sass, Max Swerdlow, Alan Van Bronkhorst, and Harold Meryman. (U.S., National Bureau of Standards. Circular No. 502.) Washington, U.S. Govt. Printing Office, August 1, 1950. 87 pp. $0.25.

L & N Bibliography of Polarographic Literature. [Bibliography No. 3-93 (1).] Philadelphia, Leeds & Northrup Company, 1950. 103 pp.

Control of Radiation Hazards in the Atomic Energy Program. U.S. Atomic Energy Commission. Washington, U.S. Govt. Printing Office, July, 1950. 230 pp., illus., diagrs. $0.55.

WRITING

Exposition for Science and Technical Students. John L. Stewart. New York, William Sloane Associates, Inc., 1950. 258 pp. $2.00.

The discussion in this book centers around the nature of scientific exposition and the relation of its requirements of precision exactness to language. Problems in the use of language, logic, outlines, and paragraphs are discussed in the first half of the book. The final half is devoted to reports. The forms and uses of reports, their formats, library research, and methods of gathering materials and observation are included. The author is Assistant Professor of English at Dartmouth College.

Aeronautical Reviews

(Continued from page 140)

The Approximate Deflection of Thin Flat Triangular Plates Subjected to Uniform Normal Load. II. J. Guest and F. S. Shaw. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 162,* November, 1950. 12 pp., illus. 1 reference.

The deflection function used in the solution solves only the kinematic boundary conditions. Courant's sensitizing method is applied to obtain an approximate solution, and this procedure is found to give a better solution than a previous method that employed the Ritz procedure.

Readers' Forum: On Plastic Buckling of Plates and a Theory of Plastic Slip. P. Cicala. *Journal of the Aeronautical Sciences,* Vol. 18, No. 4, April, 1951, pp. 285, 286, illus. 3 references.

An Experimental Determination of the Fatigue Strength of CA-12 "Boomerang" Wings. W. W. Johnstone, C. A. Patching, and A. O. Payne. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 160,* September, 1950. 53 pp., illus. 11 references.

Investigation of the fatigue strength of a stressed-skin riveted aluminum-alloy structure by a resonant vibration testing method in full-scale tests on "Boomerang" fighter wings.

Thermodynamics (18)

The Unit of Heat. *Royal Aeronautical Society, Journal,* Vol. 55, No. 481, January, 1951, pp. 52–55, illus. Recommendations of the Royal Society (London) for representing the quantities of heat, entropy, etc., in terms of the joule rather than the calorie.

On the One-Dimensional Theory of Flame Structure. Raymond Friedman and Edward Burke. *Journal of the Aeronautical Sciences,* Vol. 18, No. 4, April, 1951, pp. 239–246, illus. 16 references.

A Comparison of Quenching Distance and Inflammability Limit Data for Propane-Air Flames. Dorothy Martin Simon. *Journal of Applied Physics,* Vol. 22, No. 1, January, 1951, p. 103. 2 references.

Gas Dynamics Activities, Supersonics and Gas Dynamics Section. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Report No. ME 1950 (4),* October 1–December 31, 1950, pp. 1, 2, illus. Facilities, projects, applications, and present status of gas-dynamics research.

An Air-Flow Analogy for the Solution of Transient Heat Conduction Problems. M. B. Coyle. *British Journal of Applied Physics,* Vol. 2, No. 1, January, 1951, pp. 12–17, illus. 3 references.

Fundamental principles of an air-flow-analogy process for the solution of heat-conduction problems in metals of which the specific heat and thermal conductivity may vary appreciably with the temperature. This process involves a "lumping" procedure in which the second-order differential equation of heat conduction is replaced by a set of first-order equations. An arbitrary region of the system is assumed to be composed of cells in which the heat reservoir of each is concentrated at the center; equivalent conduction rods represent the heat flow between the centers of adjacent cells. A small prototype unit is described.

Water-Borne Aircraft (21)

Effect of an Increase in Angle of Dead Rise on the Hydrodynamic Characteristics of a High-Length-Beam Ratio Hull. Walter E. Whitaker, Jr., and Paul W. Bryce, Jr. *U.S., N.A.C.A.,* February, 1951. 42 pp., illus. 13 references.

Wind Tunnels & Research Facilities

A Flexible Nozzle for a Small Supersonic Wind Tunnel. Satish Dhawan and Anatol Roshko. *Journal of the Aeronautical Sciences,* Vol. 18, No. 4, April, 1951, pp. 253–258, illus. Design analysis.

Wind Tunnel Interference Due to Lift for Delta Wings of Small Aspect Ratio. Sune B. Berndt. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 19,* September 25, 1950. 11 pp., illus. 5 references. In English.

Correction factors are obtained for calculating the corrections to measured values of angle of attack, drag, and pitching moment for a given lift. These factors are obtained from the investigation of wind-tunnel interference due to lift on delta wings of low aspect ratio.

Experimental Investigation of the Effects of Support Interference on the Drag of Bodies of Revolution at a Mach Number of 1.5. Edward W. Perkins. *U.S., N.A.C.A., Technical Note No. 2292,* February, 1951. 50 pp., illus. 4 references.

Use of Wind Tunnel Model Data in Aerodynamic Design. R. Hills. *Royal Aeronautical Society, Journal,* Vol. 55, No. 481, January, 1951, pp. 1–19, Discussion, pp. 20–26, illus. 8 references.

The Physical Properties of Active Nitrogen in Low-Density Flow. James M. Benson. *U.S., N.A.C.A., Technical Note No. 2293,* February, 1951. 68 pp., illus. 21 references.

Investigation at velocities extending into the supersonic region; determination of the magnitude of the effects of a shock wave; examination of the aerodynamic disturbances introduced into a stream tube by the activity associated with afterglow. The results can be applied to problems of flow visualization by the nitrogen afterglow method.

Partners in Research. C. C. Furnas. *Machine Design,* Vol. 23, No. 2, February, 1951, pp. 175, 198, 200, 202, 204, illus.

Coordination between those employed in fundamental research, applied research, and development; interchange of ideas among scientists; practical limitations of security.

Military Research and Development. Philip B. Taylor. *Aeronautical Engineering Review,* Vol. 10, No. 4, April, 1951, pp. 49–51. (Excerpts from an address.) Functions and operation of the U.S. Research and Development Board.

Current Projects in Aerodynamics Laboratory, Aircraft and Allied Instrument Laboratory, Engine Laboratory, Flight Research Section, Fuels and Lubricants Laboratory, Hydraulics Laboratory, Low Temperature Laboratory, and Structures Laboratory. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Report No. ME 1950 (4),* October 1–December 21, 1950, pp. 3–19, illus.

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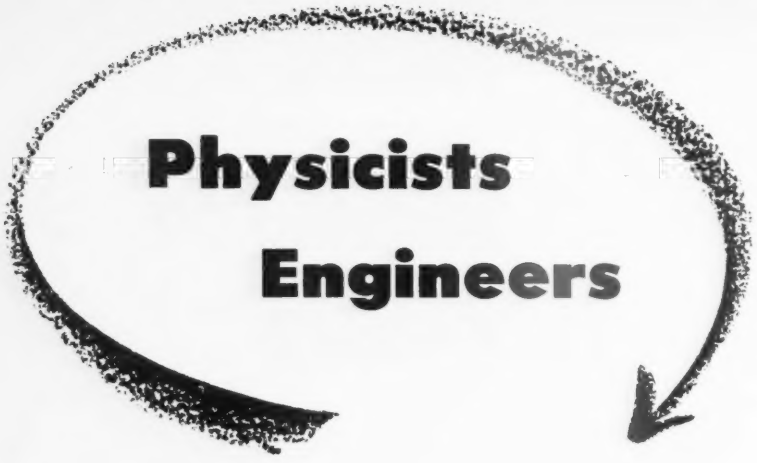

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WANTED

ENGINEERS—The following engineering positions are available at the Naval Air Development Center, Johnsville, Pa. Positions range from $3,100 to $7,600 per annum.

ELECTRICAL ENGINEERS: Aircraft Electrical Systems—Design and layout of wiring and electrical components for distribution and control of electrical power and interconnection of electrical equipment in aircraft. **Control**—Development and design of electrical systems involving sequence control devices, servomechanisms, temperature-regulated electrical heating, electrical and electromechanical components such as relays, solenoids, thermostats, electrical clutches, rotary machines, etc. **Electrical Components**—Development and design of components associated with electrical systems such as relays, solenoids, sequence control devices, voltage regulators, frequency regulators, generators, and alternators. **Test and Evaluation**—Must be experienced in laboratory or operational test procedures for complete aircraft systems or components thereof as listed in one or more of the options above. Design experience in the development of such components or systems is desirable. **Laboratory and Plant Facilities**—Survey design and planning of electrical power distribution system from high-voltage primary sources to the secondary power and lighting circuits in connection with the service to and installation of laboratory test and plant facilities, and other electrical engineering duties associated with the operation and maintenance of such facilities.

ELECTRONICS ENGINEERS: Sonar—Development and design in the field of underwater acoustics in the sonic and subsonic portions of the spectrum. **Radar**—Development and design of radar equipment involving ultra and super high-frequency components and systems. **Radio**—Development and design of AM and FM communications, navigation, and/or radio-control systems including transmitters, receivers, antennae, etc. **Control**—Development and design of electronic circuits involving autopilots, regulating devices, servomechanisms, computers, data transmission systems, and similar devices. **Radiation**—Development in the field of electromagnetic radiation and reception for infrared, visible, and radio-frequency waves.

ENGINEERING EVALUATION—Laboratory and operational engineering evaluation and test of complete electronic aircraft systems or components thereof as listed in one or more of the options above. Design experience in the development of such components of systems is desirable.

AERONAUTICAL ENGINEERS: Aircraft Structural Design—Involves the applied design of aircraft structures, or components thereof, including the installation of controls and equipment. **Aerodynamics**—Involves the estimation of pressure distributions, static and dynamic stability, and performance of aircraft or airborne components. **Stress Analyst**—Involves the calculated development of loads, the distribution of forces, and the critical appraisal of material stresses developed in aircraft structures. **Aeroelastics**—Requires specific experience in theoretical aircraft flutter and dynamic structures response problems and associated problems in aircraft structural vibrations. **Power Plants**—Must be experienced in the theoretical and practical aspects of the performance of jet engines, rocket engines, and conventional piston engines. **Stabilization**—Requires knowledge of the theoretical and design aspects of the automatic stabilization and control of aircraft with particular emphasis on the analysis of the complete airplane system performance. **Test and Evaluation of Aeronautical Components**—Must be experienced in static, dynamic, or operational test procedures for complete aircraft systems or components thereof as listed in one or more of the options above. Design experience in the development of such components or systems is desirable.

MECHANICAL ENGINEERS: Machine Design—Capable of making design and performance calculations and layouts of mechanisms and structural elements on aircraft components such as electromechanical mechanisms, fire-control equipment, antennae, cam, gear, and linkage systems, power drive systems and hydraulic components, general aircraft armament, and ground handling equipment. Must be capable of establishing tolerances and design details for economic production processing of such equipment. **Test and Evaluation**—Must be experienced in dynamic or operational test procedures for complete aircraft systems, or components thereof, as listed in one or more of the options above. Design experience in the development of such components or systems is desirable.

PHYSICISTS—Duties include theoretical and mathematical analyses, design studies, development of experimental equipment, and furnishing of technical consultation to engineers in the development, design, and evaluation of experimental and prototype equipment involving the fields of physics indicated by the options listed below. **Mechanics**—Exterior and terminal ballistics, servomechanisms, aircraft automatic stabilization and control, analog computers, and computing sights. **Electronics**—Theory and characteristics of cathode-ray and other electron tubes, electronic network analysis, radar, semiconductors. **Heat**—Thermodynamics, heat flow, radiation. **Light**—Optics, instrument design. **Electricity and Magnetism**—Electrical and magnetic circuits, electrical and magnetic properties of matter, electromagnetic fields. **Sound**—Acoustics, supersonics, underwater generation, and detection of sound. **Experimental and Test Techniques**—Specialization in planning and implementation of test programs (including flight tests) for evaluating principles and equipment covering one or more of the above options and including actual design of special test equipment. **Inquiries concerning these positions should be addressed to Industrial Relations Officer, U.S. Naval Air Development Center, Johnsville, Pa.**

Standards Engineer—Applicant must have an extensive background of experience and thorough working knowledge of all Government specifications, AN, ANA, ANC, and other standards and be capable of evaluating, on a comparative basis, items most suited for diversified structural applications in coordination with design personnel. A further requirement is a complete familiarity with the operation of the National Aircraft Standards Committee and other similar organizations engaged in issuing, interpreting, and recommending standardized parts for use in aircraft structures. A standards engineer with a formal engineering education is preferred for the reason that he must be able to rely upon his own knowledge and experience, referring only unusual problems to the supervising or senior engineer. Submit reply to Personnel Department, Sikorsky Aircraft, Bridgeport, Conn.

Weight Engineer—Applicant must have a thorough knowledge of weight investigation work, including the calculation of complicated aircraft fittings, preparation of aircraft weight studies, and a thorough knowledge of aircraft balance computations, flight ballasting schedules, and normal weight control procedures from the time of conception of design to actual manufacture of prototype and production articles. Minimum of five years' actual experience as a weight engineer is required. Submit reply to Personnel Department, Sikorsky Aircraft, Bridgeport, Conn.

Design Engineers and Layout Draftsmen—Should have minimum of 3 years' aircraft experience. Also Stress Engineers with B.S. degree. Please submit full details, including education, experience, capabilities, availability, salary requirements, etc. Address: Chief Engineer, Kellett Aircraft Corporation, Central Airport, Camden 11, N.J.

Professors of Aeronautical Engineering—Two positions on the teaching staff of the Department of Aeronautical Engineering of The University of Texas will be available beginning September 15, 1951. These positions are described as follows. **Aircraft Structures:** Duties involve the teaching of required undergraduate courses in this field, development of advanced elective and graduate courses, further development of laboratory facilities, and supervision of graduate thesis work. Qualifications should include at least a Master's degree and preferably a Doctor's degree in aircraft structures; 10 to 15 years' experience in teaching aeronautical engineering, in industrial stress analysis work, or in a structures research laboratory. **Aircraft Design:** Duties involve the teaching of required undergraduate courses in aircraft detail design, preliminary design, and a shop laboratory course in aircraft materials and processes. This staff member would also be expected to assist in the teaching of required undergraduate courses in aircraft structures and aerodynamics and in the further development of laboratory facilities in one or both of these fields. Qualifications should include at least a Bachelor's degree and preferably a Master's degree in Aeronautical Engineering; 5 to 10 years' experience in the aircraft industry in design and/or stress analysis work; an active interest in research on design and development problems. Rank and salary for these positions will depend on previous training and experience and will range from $2,700 to $7,200 for the 9-month school year. Ample opportunities are available for individual research and for participation in sponsored research projects. Interested applicants should write to Dr. M. J. Thompson, Chairman, Department of Aeronautical Engineering, The University of Texas, Austin 12, Tex., for application forms.

Aircraft Dynamics Engineers—For research work in the fields of: subsonic and supersonic flutter, vibration, dynamic loads; stability and control of missiles; and helicopter dynamic problems. Applicants must have good background in fundamentals of applied mechanics and mathematics. Advanced degree or previous experience in field is preferred. Salaries commensurate with

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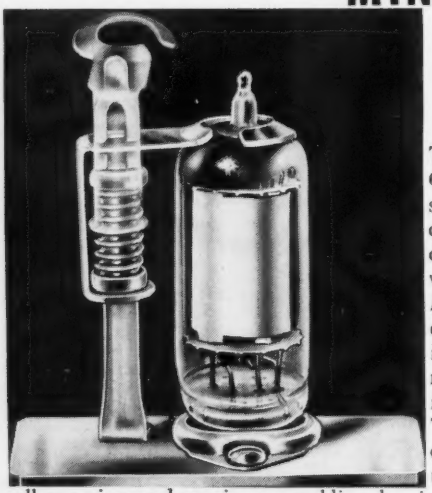

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ENGINEERS—The following vacancies exist in the Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

ARMAMENT: Armament Engineer (Bombing Systems) (MC1-805) ($6,400)—To conduct research and monitor projects pertaining to performance, characteristics, and overall technical capabilities of foreign aircraft bombing systems. **Armament Engineer (Bombing Systems) (MC1-806)** ($5,400)—To conduct research and accomplish projects determining the design and performance characteristics of foreign bombs, warheads and fuzes, bomb release gear, and special armament devices. **Ordnance Engineer (Aircraft Weapons and Accessories) (MC1-808)** ($4,600)—To investigate and determine the status of foreign research and development of such aircraft armament accessories as gun mounts and rocket launchers, chargers, firing devices, ammunition containers, ammunition boosters, firing circuits, heaters, cooling and scavenging devices, and link containers. **Mathematician (Ballistics) (MC1-811)** ($4,600)—To perform calculations in the solution of problems to determine terminal ballistics effects and the vulnerability of foreign aircraft and components to weapons fire. **Armament or Ordnance Engineer (Antiaircraft Artillery) (MC1-812)** ($6,400)—To conduct research and monitor projects pertaining to performance characteristics and the overall effectiveness of foreign antiaircraft artillery and unguided missiles. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

INDUSTRIAL MATERIALS: Chemical Engineer (Aircraft Materials) (MC1-813) ($5,400)—To conduct research and monitor projects relating to foreign research and development in the chemical engineering field as it relates to critical materials, such as rubber, plastics, and phenolics as used in aircraft, guided missiles, and related components. **Industrial or Production Engineer (Manufacturing Methods) (MC1-815)** ($5,400)—To conduct research and monitor projects pertaining to the status and trends of development in foreign aircraft industry (including air frames and missile structure) with respect to critical manufacturing methods, techniques, and assembly. **Industrial or Production Engineer (Manufacturing Methods) (MC1-816)** ($5,400)—To conduct research and monitor projects pertaining to the status and trends of development in foreign aircraft and missile propulsion and foreign armament industries with respect to critical manufacturing methods, techniques, and assembly. **Industrial or Production Engineer (Manufacturing Methods) (MC1-817)** ($5,400)—To conduct research and monitor projects pertaining to the status and trends of development in foreign aeronautical instrument industries such as flight instruments, automatic pilots, etc., with respect to critical manufacturing methods, techniques and assembly. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

NUCLEAR ENERGY: Nuclear Physicist (MC1-804) ($8,800)—To supervise the Branch responsible for estimation and determination of foreign technical accomplishments and capabilities in the field of nuclear energy as they affect abilities of foreign nations to conduct air warfare. **Nuclear Physicist or Electrical Engineer (Electronuclear Systems) (MC1-818)** ($5,400)—To conduct research and monitor projects pertaining to

the electrical and electronic aspects of nuclear energy in its application to military purposes by foreign nations, particularly as it may affect Air Force operations. **Mechanical Engineer (Mechanical-Nuclear Systems) (MC1-819)** ($5,400)—To conduct research and monitor projects pertaining to the mechanical aspects of nuclear energy in its application to military purposes by foreign nations, particularly as it may affect Air Force operations. **Nuclear Physicist (MC1-820)** ($7,600)—To conduct research and monitor projects pertaining to the status and trends of scientific advancements by foreign countries and their technical accomplishments and capabilities in the application of nuclear energy to specific problems of air warfare. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

AIRCRAFT AND PROPULSION: Aeronautical Engineer (MC1-620) ($6,400)—To conduct research and monitor projects pertaining to performance, characteristics, and overall technical capabilities of foreign piloted aircraft. **Propulsion Engineer (Rocket Power Plants) (MC1-630)** ($6,400)—To conduct research and monitor projects relating to foreign aircraft and guided-missile rocket power plants. **Aeronautical Power-Plant, Fuel, and Lubricant Engineer (MC1-611)** ($6,400)—To supervise the group conducting research on foreign fuels, lubricants, and rocket propellants. **Aeronautical Power-Plant, Fuel, and Lubricant Engineer (MC1-618)** ($6,400)—To conduct research and estimate characteristics of foreign aircraft petroleum base or synthetic fuels and lubricants. **Aircraft Pulse and Ram-Jet Power-Plant Engineer (MC1-629)** ($6,400)—To conduct research and estimate performance of technical characteristics of foreign pulse-jet and ram-jet engines. **Aircraft Power-Plant Engineer (MC1-609)** ($7,600)—To supervise group conducting research and estimating performance and technical characteristics of foreign aircraft gas-turbine, ram-jet, pulse-jet, and rocket engines. **Aircraft Performance Engineers (MC1-622, 623, 624)** ($3,825–$5,000)—Supervise (in highest grade) and perform estimates of performance, stability and control, and other flying characteristics of foreign aircraft or guided missiles. **Aeronautical Engineers (Guided Missiles Experience) (MC1-625, 626)** ($5,400–$6,400)—To conduct research and monitor projects pertaining to performance, characteristics, and overall technical capabilities of foreign guided missiles. **Aeronautical Research Engineers (MC1-614, 615, 616)** ($6,400)—To conduct research and technical analysis of foreign scientific trends and advancement in the specialized fields of the aeronautical sciences such as Structures, Dynamics (Flutter, Aeroelasticity, etc.). **Aircraft Accessories Systems Engineer (MC1-613)** ($6,400)—To conduct research and estimate performance and technical characteristics of aircraft accessories systems. **Aircraft Power-Plant Engineers (MC1-632, 634)** ($4,600–$6,400)—To conduct research and estimate performance and general technical characteristics of foreign aircraft engines. **Aircraft Power-Plant Accessories and Components Engineer (MC1-631-1)** ($5,000)—To conduct research and estimate technical characteristics and performance of foreign aircraft power-plant accessories and component parts with particular reference to fuel systems, carburation and fuel injection systems, lubricating systems, ignition systems, and power-plant control systems. **Aircraft Propeller Engineer (MC1-633)** ($5,400)—To conduct research and estimate performance and technical characteristics of foreign aircraft propellers. **Aircraft Instrument and Navigational Equipment Engineer (MC1-636)** ($6,400)—To conduct research and estimate performance and technical characteristics of foreign aircraft instruments, engine instruments, automatic control equipment, and air navigation equipment. **Aircraft Mechanical Equipment Engineer (MC1-637)** ($5,400)—To conduct research and estimate performance and technical characteristics of aircraft accessories and equipment such as hydraulic

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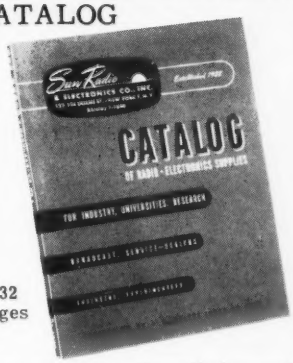

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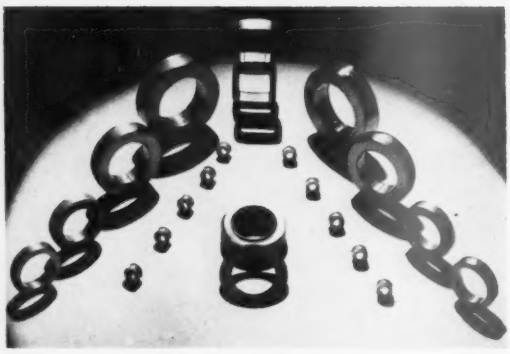

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systems, pneumatic systems, special escape equipment, landing gears, oxygen and pressurization systems, etc. **Aeronautical Power-Plant Research-Engineer (MC1-617)** ($6,400)—To conduct research and estimate performance and general technical characteristics of foreign aircraft engines. **Aeronautical Engineer (MC1-607)** ($7,600)—To supervise the group conducting research and monitoring projects pertaining to performance, characteristics, and overall technical capabilities of foreign guided missiles. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

ELECTRONICS: Electronics Engineer (MC1-703) ($8,800)—Supervises the branch responsible for estimation of performance, characteristics and technical capabilities of foreign air-borne and ground radar, radio navigation, communications and guided-missile control systems. **Electronics Engineer (Radio Navigation) (MC1-708)** ($6,400)—Conducts research in the determination of the performance characteristics and technical capabilities of foreign radio navigation systems. **Electronics Engineer (MC1-704)** ($8,800)—Supervises the branch responsible for the estimation of capabilities of foreign developments in countermeasure equipment and methods. Supervises classified electronic projects. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

296. Quality Control Engineer—With experience in aircraft engine or propeller manufacturing. Excellent opportunity with expanding aircraft manufacturer. Submit detailed résumé of experience and training.

294. Aerodynamicist—For position in charge of aerodynamic work on a new missile project. Should have 4 or more years' experience that has included aerodynamic stability analysis. Knowledge of supersonic flow as applied to missile design essential. Location—Detroit.

293. Communications Supervisor—Possessing air-line background, capable of being in full charge of operations communications program and electronics research and development in small air line.

281. Instructor—Opening in Aeronautical Engineering Department of large southeastern engineering school. Starting salary $3,074.36, plus $458.31 for summer school, if taught. B.S. in Aero. E. and M.S. in Aero. or applied mechanics required. Position to be filled before September, 1951. Send personal data, transcripts, and photograph.

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298. Aeronautical Engineer—Eight years' experience in engineering. Seven years with major United States air line as maintenance and design engineer. Presently with large airplane manufacturer as a designer. Wishes to relocate in New York area. Experienced in all phases of aircraft maintenance engineering. Design experience on aircraft components, jigs, and tooling.

295. Aeronautical Research Engineer—B.S. in A.E. from M.I.T. Will finish this year the Alexander Hamilton Institute business course. Seven years' total experience in aeronautical research, including subsonic and supersonic wind-tunnel testing, airplane performance analysis; 4 years of guided-missile work, involving aerodynamic design, ram-jet performance, and diffuser analysis. Last 2 years spent as supervisor of guided-missile design and analysis group. Some

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part-time teaching experience. Excellent references. Prefers engineering position with administrative opportunities or a position where some time can be arranged to take advanced college courses.

292. Manufacturer's Representative—Successful and dependable sales executive with long experience and wide contacts in aircraft and related defense industries, including military establishments, available immediately to handle one or more manufacturers' accounts on eastern seaboard or national territory. Glad to give further details and unquestionable sources of reference. Invite information about your product and arrangements, in confidence.

291. Aeronautical Engineer—Eleven years' experience in aircraft industry supervising design and construction of aircraft and guided missiles for military agency. First-hand knowledge of practices, procedures, and requirements of leading manufacturers and military agencies. Currently employed in a top position with proven ability. Familiar with responsible key personnel of military departments and aircraft industry. Aeronautical engineering graduate; age 37. Desires management or supervisory position in Eastern area.

290. Graduate Aeronautical Engineer—With several patents and 10 years' experience. Just recently developed new all-metal vibration isolator for manufacturer. Has time available for consultation.

289. Aeronautical Engineer—Presently Associate Professor and Head of Aeronautical Engineering Option in Mechanical Engineering at northern college. Desires position connected with aerodynamics, aerodynamic design, or engineering administration. S.M., M.I.T.; Registered Professional Engineer. Location open.

288. Management Executive—Age 48. M.S. in Aeronautical Engineering. Eighteen years as Naval Aviator. Extensive experience and participant in preparation of current mobilization plans and their logistic requirements. Retired with senior rank. Has been corporate officer and executive in private business since 1947, with last year in Europe. Wishes position with aviation or associated industry desiring executive experience in corporate and Government organization and management to have maximum participation in the National Defense Program.

287. Aviation Executive—Eleven years' broad engineering-management aeronautical background. Top level contacts in aircraft, air lines, and Government with people who count. Desires management-engineering-sales spot where extensive background and knowing people in the business are needed.

286. Mechanical Engineer—Age 24. Three years' experience with progressive aeronautical research organization in design, stress analysis, testing, and thermodynamic analysis. Prefers research and development work in Northeast or Midwest.

285. Engineer—Professor of Aeronautical Engineering at large university desires change. Chief aerodynamics engineer at major aircraft company 7 years. University position 4 years. Consultant in aerodynamics and aeroelasticity.

284. Engineer-Pilot—M.E. Degree. Experienced in aircraft design and flight test engineering. Three thousand hours as Naval Aviator. Fifty hours current jet time. Desires engineering flight-test pilot position.

282. Teaching Aerodynamics-Aerodynamicist—Dipl. Ing., Dr.-Ing. habil.; 45 years old; desires teaching or research position with university or college. Experience: 8 years with aeronautical research institutions, 9 years with leading airplane companies. Some experience as pilot, some 20 publications in the field of applied aerodynamics, some 50 technical reports, experience in lecturing. Applicant is aware of the present situation because of the military draft of students; wants, however, to establish contact for future openings. Detailed information will be submitted on request.

279. Aeronautical and Mechanical Engineer—M.S. in M.E.; Professional Engineer. Experience of 14½ years includes ram-jet and rocket test equipment and process engineering development, propeller design and vibration research, electronic automatic landing equipment development, automatic heating and machine tool design and development. Has conducted aircraft design and related courses as assistant professor in eastern college. Thirty-nine months as project officer in Air Materiel Command, Engineering Division, propeller and instrument laboratories, with final rank of Major. Has Navy and Air Force security clearance. Will relocate if attractive.

277. Sales Engineer—Position sought with firm requiring the services of a graduate engineer, age 30, capable of handling field contact responsibilities on a high plane. Single and free to travel extensively. Past experience includes technical representation, sales in automotive supply and accessory field, and flight-test engineering. Presently located on West Coast but will relocate.

267. Administration—Age 31, single. A.B. degree, University of Pennsylvania. Major in administration; courses in industrial and aeronautical engineering. Almost six years in aircraft testing in last position. Desires permanent position as junior Administrative Assistant or equivalent, with opportunity for advancement. Philadelphia area.

All-Weather Flying

(*Continued from page 47*)

ing. The other issue is turbulence. Deicing equipment in use today works tolerably well in the air but is useless on the ground. Although freezing precipitation occurs only once in a while, the effect on flying is complete grounding. The only solution at present is the laborious application of hot water and/or a mixture of alcohol and glycerine.

Air-line freight operations could provide a superb testing ground for all-weather flying if, as E. A. Cutrell pointed out, at least four airports were equipped with appropriate facilities. This means two terminals plus two alternates. Special pilots would not be needed, and best opinion is that there would not be many, if any, cancellations. An operation of this type would provide the needed practical experience and be a good test of the reliability of various devices.

A fitting climax to this meeting was provided by a question from Charles Hirsch, of the Hazeltine Electronics Corporation. I am sure he will permit a paraphrase of his remarks.

"Now that we have heard about these wonderful devices for our airplanes and our new traffic-control system, will we have agreement among the various groups to use these things in order that the aviation world will continue to make progress?"

This penetrating thought will be recognized as the crux of the matter. Know-how is available. It remains for the engineers, manufacturers, operators, pilots, regulatory agencies, and all the rest to work together to achieve the desired aims of aviation. A good way to ensure harmonious and sensible action is to learn each other's problems in open meetings such as this All-Weather Symposium.

Speaking strictly as an individual air-line pilot, I should like to add that the views expressed at this symposium make good operating sense, and I heartily endorse them. I am sure many other pilots will feel the same way.

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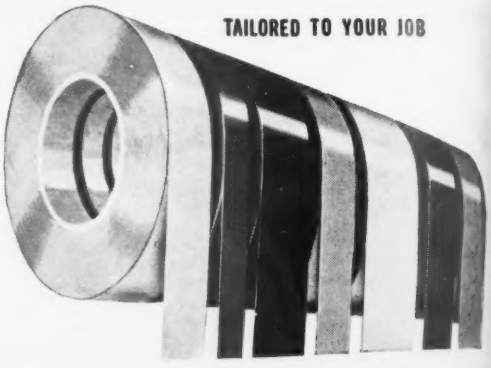

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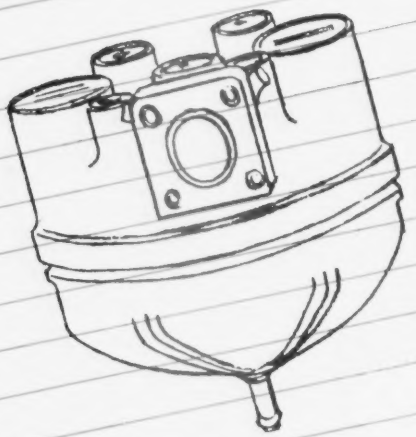

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